JPRS-JST-86-017

18 JUNE 1986

Japan Report

SCIENCE AND TECHNOLOGY

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JAPAN REPORT

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TELECOMMUNICATIONS

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AEROSPACE SCIENCES

NEWS FROM NATIONAL AEROSPACE LABORATORY REPORTED

Tokyo KOGIKEN NYUSU in Japanese May 85 pp 1-10

[Article: "National Aerospace Laboratory--May 1985 No 313"]

[Text] Business Plan for Fiscal 1985

1. Basic Policy

In the business plan for fiscal 1985 the following two matters will be carried out in accordance with the report and proposal submitted by the CAEOAT (Council for Aeronautics, Electronics and Other Advanced Technologies) and the space development plan determined by the SAC (Space Activities Commission): 1) research on aeronautic technology will be conducted by mainly establishing technologies necessary for developing future Japanese aircraft; and 2) research on space science technology will be conducted with consideration to the future direction of Japanese space development, aiming at establishing independent Japanese technology.

Research conducted by other R&D bodies and the relevant industrial world will also positively and cooperatively be promoted.

(1) Organization and Regular Staff

In fiscal 1985 research is to be conducted by an authorized strength of 456 staff members, including 343 researchers and 3 regular adjusting staff members (1 staff for 9 months and 2 for 6 months) under the organization of the Management Department, 7 research departments, 3 research groups, the Calculation Center, and the Tsunoda Branch. Also, research on the STOL (short take-off and landing) fanjet aircraft, which is the most important subject for the National Aerospace Laboratory [NAL], will be conducted in parallel with flight tests performed by the company which has manufactured an experimental aircraft. Simultaneously, a local site system will be completed in preparation for flight tests which will be performed by the NAL in fiscal 1985. Also, the STOL Project Promotion Division has been established to conduct the research smoothly and efficiently. The division will be reorganized as part of this research.

(2) Budget

In fiscal 1985 research will be conducted and facilities will be completed on the basis of the following plans with a budget of ¥10,189,255,000. The budget consists of a cost of ¥10,009,652,000 for the test and research institutes of the Science and Technology Agency, a cost of ¥139,197,000 (expenditure consignment) for R&D of technology for conserving energy on a large scale advocated by MITI (Ministry of International Trade and Industry), and a cost of ¥40,406,000 (change) for testing and research on prevention, etc. of environmental pollution conducted by national bodies of the Environment Agency.

Also, a cost of the science and technology promotion arrangement is not included in the budget because its amount is pending.

(3) Research Plan

In fiscal 1985 research in the following seven fields will be conducted: 1) STOL aircraft; 2) jet engines; 3) jet transport airplanes, etc.; 4) space transportation system; 5) artificial satellite system; 6) numerical value simulation technology, etc.; and 7) promoting research of the seven fields in application of aeronautic and space technologies to other fields. Particularly, "Research on the Fanjet STOL Aircraft" related to aeronautics will be conducted under an overall system. Also, "Research on Liquid Oxygen and Fluid Rocket Engine Elements," and "Research on Basic Satellite Technology" related to space will be conducted continuously as special research.

Particularly, the trial manufacturing work and research on a high-pressure liquid oxygen turbopump for the LE-7 necessary for the H-II rocket will be carried out in the "Research on Liquid Oxygen and Fluid Rocket Engine Elements." In addition, the NAL will be partially in charge of the "Research and Development of High-Efficient Gas Turbine" and the "Research and Development of the General-Purpose Stirling Engine" based on the "Research and Development of Technology for Large-Scale Energy Conservation" advocated by MITI, and research on technology for preventing environmental pollution will be conducted at a cost of testing and research on prevention, etc., of environmental pollution conducted by national bodies of the Environment Agency. When necessary, space research will be positively conducted in collaboration with the NSDA (National Space Development Agency), and independent technologies will be established. Also, when it is recognized as being particularly necessary to enhance aeronautic and space scientific technologies, the NAL will perform tests requested by national test and research bodies, private companies, etc., and will use the facilities of these bodies, companies, etc.

(4) Plan for Maintaining Research Facilities

In fiscal 1985, the Gifu Flight Experimental Building necessary for conducting flight experiments of a low noise STOL experimental aircraft will be completely ready, and a high-pressure liquid oxygen turbopump test facility necessary for conducting research on large rockets and a test building for

receiving the facility will be completed. Also, exceedingly outdated large research facilities, particularly transsonic wind tunnels and hypersonic wind tunnels, will be modified.

2. Research Plan

The number of research items in fiscal 1985 is 123, including 22 items of research based on the "Research and Development of STOL Aircraft," 4 items of 2 special research projects on space and scientific technology, 5 items of 2 research projects and developments of technology for conserving large energy, advocated by MITI, and 2 items of expenditures on test and research on prevention, etc., of environmental pollution conducted by national bodies of the Environment Agency. An outline of the main research in every field in fiscal 1985 is as follows:

(1) Research on STOL Aircraft

With regard to the fanjet STOL aircraft having a short take-off and landing capacity and low noise expected to be active in future air transport, research on such aircraft will be conducted by mainly developing experimental aircraft in which various new technologies are incorporated, and the practicality of new technologies such as STOL technology, etc., will be demonstrated by performing flight experiments.

Research on Fanjet STOL Aircraft (fiscal 1977 to 1987)

A. R&D of low noise STOL experimental aircraft (fiscal 1977 to 1985)

Basic design work was started in fiscal 1977 and the work of manufacturing an experimental aircraft was started in fiscal 1979. In fiscal 1985 the experimental aircraft will be completed by conducting the overall assembly and tests following on from previous fiscal year.

a. Work of manufacturing airframe (overall assembly and testing) (fiscal 1982 to 1985)

Respective components such as the high-lift device, flight control system, airframe (modified portions of C-1 and portions common with C-1), FJR engine, etc., will be assembled, and overall ground tests, and in-house flight tests will be performed to check the safety and function of the experimental aircraft. In fiscal 1985, the overall ground tests and in-house flight tests will be performed, and the experimental aircraft will be received.

B. Facilities Related to Flight Experiments (fiscal 1982 to 1986)

Facilities necessary for conducting flight experiments of the experimental aircraft will be maintained.

a. Work of manufacturing measuring systems (fiscal 1982 to 1986)

The airborne and ground measuring systems necessary for obtaining and processing data on flight experiments of the experimental aircraft will be maintained. In fiscal 1985 the maintenance of the ground measuring system will be carried out following on from the previous fiscal year.

b. Gifu Flight Experimental Building (fiscal 1984 to 1985)

The ground measuring system, etc., necessary for performing flight experiments on the experimental aircraft will be stored and a building necessary for discharging duties related to the flight experiments will be completed.

C. Flight Experiments (fiscal 1985 to 1987)

Flight experiments will be performed by using the STOL experimental aircraft in which various new technologies such as powered high-lift technology, computer flight control technology, etc., are adopted. The effectiveness of these technologies and the practicality of low-noise STOL technology obtained by integrating these technologies will be demonstrated, and technical problems related to operation of fanjet STOL aircraft will be taken up and solved.

a. Operation of experimental aircraft (fiscal 1985 to 1987)

Before performing flight experiments, necessary fuel and lubricants will be procured, and flight and technical staffs for supporting the flight experiments will be ensured. In fiscal 1985 fuel and lubricants necessary for performing the flight experiments will be procured, and the labor power of the flight and technical staffs for supporting the flight experiments will be ensured.

b. Maintenance of experimental aircraft (fiscal 1984 to 1987)

The airframe and engines of the experimental aircraft will be maintained, modified, etc., to smoothly perform the flight experiments of the experimental aircraft. In fiscal 1985, replacement parts for the airframe will be procured following on from the previous fiscal year, and the maintenance, inspection, and engine overhaul of the experimental aircraft will be carried out to perform the flight experiments smoothly. Also, measures for enhancing the flight performance will be taken on the basis of results obtained in the development process of the experimental aircraft.

c. Relevant supporting test (fiscal 1984 to 1987)

The safety and efficiency of the flight experiments of the experimental aircraft will be ensured, and tests indispensable to enhance the accuracy of experiments and analyses will be performed in parallel with the flight experiments or priority of the flight experiments. In fiscal 1985 preparations for low-speed and high-speed wind tunnel tests will be made, and the flight control system functional tests, flight simulation tests, structural and strength tests, and engine operating tests will be performed.

d. Gifu district management (fiscal 1984 to 1987)

The management of facilities in Gifu district, work of installing communication, radar equipment, etc., and procurement of kits for crewmen of the experimental aircraft will be carried out.

D. Technical Research (fiscal 1977 to 1987)

Research on elemental technology particularly important to carry out the development of the STOL fanjet aircraft will be conducted, the development of the experimental aircraft will be supported, and new technologies necessary for future STOL fanjet aircraft will be established.

a. Research on aerodynamic characteristics (fiscal 1977 to 1978 and fiscal 1982 to 1987)

Research on aerodynamic characteristics for accurately estimating flight allowable areas will be conducted with a view to enhancing the performance of the STOL fanjet aircraft and ensuring the safety of the flight. In fiscal 1985 the applicable range for the airframe in the low-speed area will be extended by improving the planned program concerning low-speed aerodynamic characteristics, and wind tunnel tests will be performed using a model modified in the previous fiscal year. Also, with regard to high-speed aerodynamic characteristics, analytic programs, including data on nacelle and engine exhaust, will be developed.

b. Research on flight performance (fiscal 1977 to 1987)

Research on flight performance will be conducted in accordance with landing approach systems such as sharp-angle approach, two-stage approach, curvilinear approach, etc., required for the STOL fanjet aircraft. In fiscal 1985 portions of the gust responding control equipment related to the lateral motion mode such as side slip, turn, etc., will be manufactured and evaluated, and effects on flight performance will be studied.

c. Research on engine outfitting (fiscal 1977 to 1987)

Research on the propulsion system and engine outfitting system suitable for the STOL fanjet aircraft will be conducted. In fiscal 1985 the accuracy of the program for analyzing the flight characteristics developed the previous fiscal year will be enhanced, research on the exhaust mixing nozzle will be conducted, and digital control technology software suitable for the STOL aircraft will be developed.

d. Research on structure (fiscal 1978 to 1987)

Research on reducing the structural weight of the STOL fanjet aircraft will be conducted using lightweight composite materials. In fiscal 1985 the development of the optimum design general-purpose software will be carried out following on from the previous fiscal year, a model for performing flutter tests will be designed and manufactured for the purpose of

optimizing the fibrous direction of composite materials, and the software will be inspected.

e. Research on control system (fiscal 1978 to 1987)

Research on technology for using optical fiber will be conducted to enhance the reliability of the automatic flight control system of the STOL fanjet aircraft. In fiscal 1985 a mounting type optical bus I/O (input-output) signal processing section, which is a part of the DFBF (digital fly by fiber), will be manufactured. In addition, the following projects will be carried out as main regular research on STOL aircraft: 1) research on overall performance of STOL aircraft; 2) research on aerodynamic structure concerning high-lift wing; 3) research on strength of airframe at high temperatures; 4) research on damage development of glass/polyimide materials in high-temperature, acoustic, and fatigue environments; 5) research on flight simulation technology; 6) research on stable controllability of aircraft; and 7) research on STOL navigation system.

(2) Research on jet engine

Research on control of jet engines will be conducted mainly using FJR engine aimed at enhancing the reliability and performance of respective engine elements. Also, overall investigation and research on next-generation engines and future type engines will be conducted, and research on engine elements which form the foundation of independent technology will be conducted.

A. Research on Overall Performance of Aeroengine

Overall research and investigation on future type engines, such as variable-shaped engines, etc., will be carried out. In fiscal 1985, a study on enhancing the calculation accuracy of the design program of an engine cycle developed the previous fiscal year will be conducted, and investigation and research on next-generation engines will be carried out.

B. Research on Measurement and Control of High-Performance Jet Engines

Research on the measurement of high-accuracy, multivariable control will be conducted with consideration to high-performance jet engines. In fiscal 1985 research and trial manufacturing work of sensors accompanied by controlling the wing tip clearance between compressor or turbine and its case will be carried out, control experiments will be conducted using a simple model, research on signal processing methods, etc., necessary for controlling engines will be conducted following on from the previous fiscal year, and multivariable engine control systems will be evaluated using the computer simulation method.

C. Research on Aerodynamic Elements of Fluid Machines

Research necessary for enhancing the aerodynamic performance of respective elements such as fan, turbine cascade, exhaust duct, etc., will be conducted to enhance the overall performance of jet engines, and software will be

developed by conducting numerical experiments. In fiscal 1985 aerodynamic tests on airfoil will be performed using a wing cascade tunnel and the wing cascade design will be systematized by performing numerical experiments to enhance the performance of the fan and turbine cascade. Also, respective codes of the engine intake and exhaust duct will be developed so they can be generally used. In addition, the following projects will be carried out as main regular research on jet engines: 1) research on factors which have an influence on compressor performance; 2) research on enhancing combustor performance; 3) research on turbine cooling; 4) research on high-temperature, high-load turbines; 5) research on strength of members of prime mover; 6) research on performance and life span of ball-and-roller bearing.

(3) Research on Jet Transport, etc.

Research on jet transport, etc., will be conducted together with research on technologies for conserving energy, enhancing safety, and adapting jet transports themselves to environments.

A. Research on Overall Dynamic Characteristics of a Transsonic Range

Research on the shape of an airframe having a high-economy efficiency and a small amount of resistance at a transsonic cruising range will be conducted to enhance the economic efficiency of aircraft. In fiscal 1985 the development of analytic programs of transsonic flow around the entire shape (including engines) of the aircraft will be carried out. In addition, functions of the aerodynamic design system will be enhanced. Explaining in detail, analytic software such as low-speed overall analytic program, two-dimensional airfoil analytic program according to the Navier-Stokes equation, etc., will be added to the system, and it will become possible to determine the direction and distribution of the profile thickness and wing span. Also, natural laminar airfoils, plane of wings, etc., will be designed using the system, and the shape of the airframe will be brought to the optimum by performing wind tunnel tests. Also, research on testing methods of a power-driven model will be conducted continuously using a transsonic wind tunnel to clarify the influence of engine exhaust on the airframe.

B. Investigation and Research on Technology for Economizing Aircraft Fuel

Investigation and research on the present status and future prospects concerning technology for economizing the energy of aircraft will be conducted. In fiscal 1985 FSW (forward swept wing) and sweptback wings will be subjected to transsonic wind tunnel tests, and the results will be compared and studied as a part of the work of evaluating the energy conservation of planes of various wing designs. Also, investigation and study of the following two methods will be conducted: 1) flight experimental methods of demonstrating technology for manufacturing ultra-lightweight composite materials and for controlling laminar flow, and 2) flutter testing method by using an unmanned aircraft.

C. Research on Active Control of Aeroelastic System

Research on active control technology for reducing the gust load and realizing the restraint of flutter by automatic control will be conducted to enhance the safety of aircraft and further economize aircraft fuel. In fiscal 1985 a system for reducing the gust load incorporated in a model having cantilever wings will be subjected to demonstration tests in a large low-speed wind tunnel, and the work of manufacturing an overall model will be started in order to perform experiments on active control technology. In addition, the following matters will be conducted as main regular research related to jet transport, etc.: 1) research on low-temperature wind tunnel; 2) research on airfoil for controlling laminar flow; 3) research on aeroelasticity; 4) research on structural strength of airframe; 5) research on fatigue and strength of structural components; 6) research on strength and fatigue of structure of composite materials; 7) research on reduction in noise emitted by aircraft; 8) research on flatness of runway related to taxiing load; 9) research on helicopters; 10) research on indication of future type cockpit; and 11) research on workload of pilots.

(4) Research on Space Transportation System

Research on space transportation systems will be conducted following or from the previous fiscal year with a view to further enhancing the performance of liquid oxygen and fluid rocket engines. Particularly, trial manufacturing work and research on a high-pressure liquid oxygen turbopump for the LE-7 necessary for the H-II rocket will be carried out. In addition, research on rocket applied-technologies such as recovery technology and rendezvous/docking technology will be conducted. Also, research on future type rockets will be conducted using independent technologies, and research on elemental technologies having a high advancement necessary for developing the rocket applied-technologies will be conducted.

A. Research on Elements of Liquid Oxygen and Fluid Rocket Engines (special research: fiscal 1977 to 1987)

Research related to the LE-7 engine at the first stage of the H-II rocket will be conducted continuously. The LE-7 is a liquid oxygen and fluid rocket engine which will be used to launch 2-ton-class large geostationary satellites in the 1990's. In fiscal 1985 with regard to the turbopump system, the primary trial-manufactured, high-pressure, liquid-oxygen turbopump for the LE-7 will be completed and immediately subjected to various tests. Tests for enhancing the performance of an inducer will be performed. Bearings and seals will be manufactured on an experimental basis and subjected to tests. Combustors will be subjected to high-pressure two-stage combustion tests and fluid cooling tests by using a model of a cooling path. Research on methods of manufacturing high-pressure combustors will be conducted.

B. Research on Recovery Technology

Research on recovery technology will be conducted for the purpose of establishing the recovery technology which will be required for performing experiments on materials, etc., in space. In fiscal 1985 research on the ablator reusing type thermal protective system and thermoaerodynamic design technology will be conducted following on from the previous fiscal year. In addition, the following matters will be conducted as main regular research on the space transportation system: 1) research on liquid propellant rocket engine system; 2) research on combustion of solid propellant rocket fuel; 3) research on combustion of air breathing type rocket fuel; 4) research on performance of rocket engines at high altitudes; 5) research on aerodynamic performance of large rockets; 6) research on rendezvous and docking technologies; and 7) research on navigation guidance sensor systems.

(5) Research on Artificial Satellite System

With regard to the artificial satellite system, research on control of satellites having a flexible structure and research related to basic technology of satellite components will be conducted. Satellite components such as bearings, etc. are common in varous satellites. Space experiments will be performed using the space shuttle, and basic research on remote-sensing systems, etc. will be conducted. Also, elemental technologies concerning space stations will be developed, and research related to use of the space station will be conducted.

A. Research on Basic Satellite Technology (the following items are special research after fiscal 1980)

Various, basic common technologies which constitute satellites will be established to increasingly promote domestic production work using independent technologies, and the performance of satellites will be enhanced to cope with the mission which will intensively have multiformity and will be highly advanced in the future.

a. Research on space bearings (fiscal 1981 to 1985)

Research on magnetic bearing will be conducted, and the technology for designing magnetic bearing will be established. This magnetic bearing is required for lengthening the lifespan of flywheels for controlling the attitude of satellites with high accuracy. It must be possible to rotate the magnetic bearing at a high speed and with low-power consumption. In fiscal 1985 the magnetic bearing flywheel (momentum wheel) for high-speed rotation will be designed, manufactured, and subjected to floating rotation experiments. Also, the biaxial control type magnetic bearing flywheel manufactured in the previous fiscal year will be installed on the H-I rocket, the H-I rocket will be launched in the winter of 1986, and tests for checking the function of the H-I rocket will be performed in space environments.

b. Research on control of satellites having a flexible structure (fiscal 1982 to 1986)

Research on vibration characteristics and control characteristics of satellites having a flexible structure will be conducted to establish the technology for controlling the attitude of satellites having a flexible structure. The structure of solar cell paddles, various antennas, etc., of these satellites is liable to be deformed in proportion to the fact that the size of artificial satellites is increased. In fiscal 1985 a simulation model of the STOL aircraft, which has been maintained up to the previous fiscal year will be partially modified, control experimental equipment will be maintained and completed, and vibration tests on the structure of simulation paddles of the STOL aircraft will be performed.

c. Research on xenon ion engine

Research on the xenon ion engine will be conducted to use the engine for the purpose of controlling the position and attitude of artificial satellites and transferring the orbit of these artificial satellites. As compared with the engine of chemical rockets, it can be expected that the xenon ion engine will be very excellent in respect of payload. In fiscal 1985, a cusped magnetic field type electrodischarging room will be made on an experimental basis with a view to enhancing the efficiency of an ion engine with a diameter of 12 centimeters in which xenon is used as a propellant. The room will be operated and subjected to performance tests.

B. Research on Space Station

Research on elements which constitute the space station, fundamental technologies for supporting experiments, and use of the space station will be conducted. In fiscal 1985 research on technologies related to elements which constitute the space station will be conducted. Namely, research on technologies related to extension experiment stand, life science experiment supporting equipment, and low gravity experiments will be conducted. Also, research on use of the space station will be conducted--that is, research on the solar furnace which will be used in space, technology for maintaining life of the closed system, work of refining low-gravity materials, etc., will be conducted. The elements are used in the solar furnace.

C. Research on Basic Technology for Using Space; FMPT (first material processing tests)

The NAL will conduct basic research on invention of new materials by using the space shuttle and space laboratory, and will participate in the FMPT project. The participation themes are "Research on Acoustic Wave Interference History and Behavior of Droplets in Acoustic Wave Floating Equipment," "Clarification of Behavior of Bubbles in Places Having a Temperature Gradient and Ultrasonic Stationary Waves," and "Research on Perception-Action Functions in a Weightless State (Research on Manual Control Characteristics)." In fiscal 1984 the NAL will perform preliminary ground experiments on the NAL's research theme in the case of NAL participating

in the FMPT Project, and will establish the technology for performing experiments in space environments following on from the previous fiscal year.

D. Research on Remote Sensing Work Using Artificial Satellites

Research on sensors having high resolving power, technology for processing large-scale image data at high speed and with high accuracy and onboard processing technology will be conducted. The sensor is used for future type earth observation satellites. In fiscal 1985 research on processing technology will be conducted following on from the previous fiscal year. The processing technology will be required for effectively using multidimensional, large-scale image data of the MOS-1 marine observation satellite, etc., scheduled to be launched in fiscal 1986. In addition, the following projects will be conducted as main regular research on artificial satellites: 1) research on standard of evaluating reliability of upstage motor; 2) research on contact type bearing; and 3) research on triaxial control of artificial satellites.

(6) Research on Numerical Simulation Technology, etc.

R&D of numerical simulation technology will be carried out to excessively enhance the capacity of R&D of innovational aircraft technology and space technology related to energy-conservation aircraft, high-performance engines, etc.

A. Research on Numerical Simulation

Research on numerical simulation systems will be conducted. The system will play a leading role in the future numerical simulation technology. Also, research on high-speed numerical simulation technology will be conducted in parallel with the above research. In fiscal 1985 investigation and research on function, constitution, etc., of systems of numerical simulators will be conducted. Also, research on parallel calculation methods and parallel program technology will be conducted.

B. Research on Numerical Simulation Technology

Research on numerical simulation technology for aerodynamics and structure will be conducted. The technology is important for carrying out the R&D of aviation and space technology. In fiscal 1985 research on viscous flow, inviscid flow and numerical simulation technology for structures laminated by composite materials will be conducted. The viscous flow is related mainly to airfoil, wing, and engine wing cascade of aircraft. The inviscid flow is required for carrying out the aerodynamic design and analytical work of aircraft for wing body and overall model.

C. Development of General-Purpose Software

General-purpose software will be developed on the basis of results obtained by conducting research on numerical simulation technology, and will be fully utilized in the future R&D work. In fiscal 1985 a general-purpose software

for inviscid flow will be developed, and the level of the aircraft design systems promoted since previous fiscal year will be enhanced. The software is related to wing body, overall body, air intake, wing cascade, etc. of aircraft. Also, with regard to the structure of aircraft, general-purpose software for strength of composite materials, buckling analysis, etc., will be developed. In addition, the following matters will be conducted as ordinary research which will be conducted by mainly using large computers: 1) aerodynamic research on aircraft in upper atmospheres; 2) research on rarefied air current; 3) aerodynamic research on rockets; 4) research on orbit estimation; and 5) research on nonlinear phenomena.

(7) Research on Application of Aviation and Space Technology to Other Fields

Research on application of technologies to other fields will be conducted to raise the people's living standards. The technologies have been obtained by conducting research on aviation technology and space and scientific technology.

A. Research on high-efficient gas turbines (research according to R&D of technology for conserving large energy, advocated by MITI: fiscal 1978 to 1987)

Research on technology for low-pollution, highly-efficient gas turbines will be conducted by combining a gas turbine with a steam turbine in order to develop a compound generation system having an overall efficiency of 55 percent or more. The steam turbine is driven with high-temperature steam obtained by using exhaust gas generated from the gas turbine. The gas turbine plays an important role in the system. The NAL will take partial charge of the following R&D.

a. R&D of technology for compressors

Research on unsteady-state air force which acts on stationary and rotor blades of compressors will be conducted to enhance the reliability of compressors for highly-efficient gas turbines. In fiscal 1985 fluctuating air force which acts on blades will be clarified using an annular oscillating cascade tunnel. Forced oscillation on the cascade of compressors is caused by fluctuating air force.

b. R&D of technology for combustors

Technology for designing high-pressure and reheating combustors for highly-efficient gas turbines will be established. In fiscal 1985 combustion tests, etc., will be performed using high-pressure and intermediate-pressure combustion testing equipment to raise the durability of high-pressure and reheating combustors.

c. R&D of technology for turbines

Technology for designing high-temperature, high-pressure, and highly-efficient turbines will be established. In fiscal 1985 overall film cooling turbine blades whose cooling medium is a mixed gas of steam and air will be subjected to cooling performance tests, the tip clearance between rotating turbine blades and casing inside will be measured, tests and research on mechanism for controlling tip clearance will be conducted, and design technical data on increasing performance will be obtained.

B. R&D of General-Purpose Stirling Engine (Research according to R&D of technology for large-scale energy conservation advocated by MITI: fiscal 1982 to 1987)

Technical research will be conducted to put to practical use engines for airconditioning heat pumps and 3-kw-class and 30-kw-class Stirling engines suitable for small power source. The NAL will take partial charge of the following R&D:

a. Research on low-pollution, high-load combustion technology

Basic data will be obtained to decrease the level of pollution generated from combustors of Stirling engines and to enhance the load of these combustors, and technology will be established to accurately evaluate the combustion performance and exhaust characteristics. In fiscal 1985 equipment for measuring the radiation of burner flame and equipment for overall measuring of the laser will be maintained. Temperature in combustors and concentration, components, and flow rate of poisonous gas will be measured, and a CAD (computer aided design) system for designing burners will be made on an experimental basis.

C. Research on Low-Noise, Open-Type Rotating Blades (Research using cost of tests and research on prevention, etc., of environmental pollution, conducted by national bodies of the Environment Agency: appropriated in a lump by the Environment Agency: fiscal 1982 to 1985)

Sufficient measures have not yet been taken to lower the level of noise emitted from fans, propellers, helicopters, and wind force turbines having open-type rotating blades. The noise emitted from these machines has a relatively low frequency. Therefore, the generation and propagation mechanism of the noise will be experimentally clarified with a view to lowering the noise level. In fiscal 1985 noise characteristics of contra-rotating propellers will be clarified, and technical data on low-noise, open-type fans, helicopters, and wind force turbines will be obtained and summarized.

D. Research on the Decrease in the Amount of NOx (nitrogen oxide) Using Combustors for Gas Turbines (Research using the cost of tests and research on prevention, etc., of environmental pollution, conducted by national bodies of the Environment Agency: appropriated in a lump by the Environment Agency: fiscal 1982 to 1985)

Research on the combustor will be conducted to decrease the amount of Nox generated from gas turbines. Combustors must be able to burn low-NOx at their wide operating ranges. In fiscal 1985 research on low-NOx will be conducted by applying the rarefied and premixed combustion method to a model of combustors for gas turbines, and technical data on the low-NOx will be summarized. In addition, the following projects will be conducted as research on the application of aviation and space technology to other fields: 1) research on technology for using wind force and thermal energy (research using the cost of the science and technology promotion arrangement: scheduled); and 2) research on the invention of new materials in a weightless state (research using the cost of the science and technology promotion arrangement: scheduled).

3. Plan for Maintaining Research Facilities

Facilities necessary for enhancing aviation, space, and science technologies will be maintained. (Gifu Flight Experimental Building is mentioned in the "Facilities Related to Flight Experiment for Research on STOL Fanjet Aircraft.")

(1) High-Pressure, Liquid Oxygen Turbopump Testing Facilities (fiscal 19874 to 1985)

A. Testing Facilities (fiscal 1984 to 1985)

B. Testing buildings (fiscal 1984 to 1985)

High-pressure, liquid oxygen turbopump testing facilities necessary for conducting research on liquid oxygen and fluid rocket engine elements will be completed. Also, testing buildings for storing these facilities will be completed.

(2) Special Modification of Large Research Facilities

All facilities will be fully utilized by modifying large research facilities which have deteriorated extremely.

A. Special Modification of Transsonic Wind Tunnel (fiscal 1985 to 1987)

The work of renewing main fan-driving facilities for a transsonic wind tunnel will be started.

B. Special Modification of Hypersonic Wind Tunnel

Of the control facilities for a hypersonic wind tunnel, a model controlling equipment will be modified.

(3) Investigation on Numerical Simulators (fiscal 1985)

The system configuration of numerical simulators will be investigated and studied. These numerical simulators must be suitable for conducting R&D of aviation and space technologies.

Engines Have Been Installed in the Asuka STOL Experimental Aircraft

The Asuka equipped with FJR 710/600 S engine No 5 (as a test engine) has been subjected to a second flight test. The function of the lubricant circulating system of the engine has been enhanced. The test has successfully been completed. (Refer to NAL News No 309) The modification work of the lubricant circulating system of FJR 710/600 S engines Nos 1, 3, and 4 was started in November 1984. These engines are mounted in the Asuka, low-noise STOL experimental aircraft. Continuously, FJR 710/600 S engine No 2 used in the first flight test was overhauled and modified. These four engines had successively been delivered to KHI (Kawasaki Heavy Industries, Ltd.) during period from December 1984 to January 1985.

Before being subjected to shipping operation tests, these engines were equipped with a generator and a hydropump which are auxiliary equipment of the airframe on the assumption that these engines be mounted on the experimental aircraft. The engines were subjected to full load tests and the performance and functions necessary for controlling the experimental aircraft were checked. The performance and functions are engine performance, acceleration characteristics, starting characteristics, etc., during air-bleed and non-air-bleed.

The QEC (quick engine change) build-up work was started at KHI as soon as the four engines were delivered to the company. The work was smoothly carried out and all the engines were completely mounted on the Asuka on schedule in March 1985.

(STOL Project Promotion Division, Experimental Aircraft Development Section and Engine Technology Development Section)

20,143/9365
CSO: 4306/2564

DEFENSE INDUSTRY

CONTINUED HIGH EQUIPMENT PRODUCTION COST NOTED

Tokyo JIHYO in Japanese Apr 86 pp 116, 117

[Article by Sugita]

[Text] High Equipment Production Cost Discussed

Managing Director of Japan Ordnance Association, Mr Sakichiro Ono

It is a defense issue which becomes one of the focal points for budgetary deliberation in the Diet every year. Defense spending amounts to 0.993 percent of the GNP. The difference between that and 1 percent of GNP ceiling is Y23.5 billion. Indefinitely, the defense spending figure will remain near 1 percent. In the last Diet session, the emergency response to the sea-lane issue was discussed. However, my impression is that both the ruling party and the opposition parties did not deliberate the issue very seriously. Rather, they left the impression that they were simply trying to save face. As a matter of fact, "defending a nation" and 1 percent of GNP ceiling are different areas of discussion.

One day, I visited the Japan Ordnance Association (chairman: Mr Tadahiro Sekimoto) in Shimbashi, Tokyo, and met Mr Sakichiro Ono, the managing director.

The Association was founded in 1951. It started with the Japan Technology Production Cooperation Association, a nebulous name. It was natural that it used such a nebulous name because its purpose was to cooperate in researching the possibility of ordnance production for the U.S. military during the Korean war, and to make arrangements for improving the system of domestic ordnance production under the severe occupational policy. In 1952, with the issuance of permission to produce ordnance in Japan by the General Headquarters, special U.S. military procurements started. The name was then changed to the Ordnance Production Cooperation Association. The current name was selected in 1953, after its business of special procurements started picking up.

It was not until that time that the association, both nominally and substantially, became a group of the defense industry, and this established the foundation of today's industry.

The defense industry flourished for 4 years during the Korean war special procurements. It contributed to the reconstruction of postwar Japan by earning approximately Y52 billion in hard currency. However, since then, special procurements decreased, and the industry started to depend fully on the demands of the Defense Agency. The budget for the first defense improvement plan between 1958-60 was approximately a Y3.3 billion.

Full scale domestic equipment production started with the third defense plan in 1967. Domestic equipment production with the introduction of foreign technology also started.

The oil shock totally changed the position of the defense industry. "During that time, trading companies paid daily visits to the defense industry, saying that oil could be obtained in abundance if Japan exported our ordnance to oil producing countries." However, it was not allowed because of the 3 principles of ordnance exports.

Yet, the industry started to gain stability after the trough in 1976, and it has maintained stability up to today. Currently, the association has 99 full member firms, 34 associate member firms, and approximately 120 individual members. The total annual sales by the members is approximately Y500 billion.

What immediate problems face the Japanese ordnance industry, which is under the 3 principles of ordnance exports and the basic stance of putting a priority on defense?

Mr Ono says: "Defense equipment is always considered on the basis of the U.S.-Japan Mutual Security Treaty, and the priority is on defense rather than offense. One thing that can be pointed out is the importance of domestic production with the use of original Japanese technology. Even though U.S. equipment is supplied, it does not fit the Japanese physique. Because they are handling weapons, they have to be able to use them without difficulty. If so, then domestic production becomes necessary. The industry has achieved a high level of technology.

However, when the Defense Agency is the only customer, the cost of production tends to be high because of the small order of producing the variety of equipment. Thus, the cost of production remains high. For instance, Japanese ordnance are suited for Southeast Asians whose physiques are similar to that of the Japanese, but exports of ordnance are banned. Unlike other nations, Japan does not have any place where they can ask for trade-ins. Therefore, there is a definite reason why the cost of Japanese ordnance is high." It is not only ordnance itself which Japan cannot export but also plants, equipment and technology related to the production of ordnance.

Recently, the U.S. started to insist vigorously that Japan should defend itself as much as possible, as a result of U.S. financial difficulties and the expansion of areas for the U.S. to defend. Yet, overdoing defense may threaten other nations. We occasionally hear that the real U.S. intention is to have Japan control defense production at a certain level.

The basic stance should be to recognize the fact that Japan may get burnt if it makes awkward approaches to defense production, but it is necessary to nurture certain defense production capabilities appropriate for the nation. Switzerland is permanently a neutral state, but each individual has a strong commitment to defending the nation. I will defend my country with my own hand. This is an overwhelming drive in the Swiss." This was Mr Ono's impression when he visited Switzerland.

What is deterrence? It has been 40 years since the end of World War II. How should a peacekeeping defense power, which boasts of being a cultural nation, be established? Looking toward the 21st century, this is a big issue which the Japanese have to deal with.

13078
CSO: 4306/2060

NEW MATERIALS

NEW DESIGN CONCEPTS IN AUTOMOBILE TECHNOLOGY REPORTED

Tokyo NIKKO MATERIALS in Japanese Sep 85 pp 12-16

[Text] Ten years have passed since reduction in vehicle weight through use of composite materials, considered a method to improve automobile fuel consumption dramatically, thereby saving limited deposits of oil resources, has been under active study. During this time period, the trial manufacture of an experimental car and the application of this method to the racing car have been seen. In recent years, the applied research of composite materials for automobile parts, such as the trial manufacture of a CFRP (Carbon Fiber Reinforced Plastics) spring and FRP (Fiber Reinforced Plastics) engine parts, has been rapidly conducted. Due mainly to the problem of high manufacturing cost, however, a tendency toward the full-scale application of composite materials to automobile body structure is still far from actualization. According to the study of material revolution and the analysis of an impact on the next generation industry and technology, commissioned by the Ministry of International Trade and Industry (MITI) in 1978, the establishment of the FRP automobile body concept was an important subject as well along with other fundamental techniques in order to apply CFRP to the body.

The foundation, Japan Automobile Research Institute, formed the five-member committee to study the third generation automobile structure which looks for the establishment of the FRP automobile concept. The five members are M. Takehana, professor, Department of Industrial Design, Chiba University; K. Goto, director of Japan Automobile Research Institute; Y. Minoda, technical director of the Next Generation Metal & Composite Materials Research and Development Association; H. Momoshima, representative director of Composite System Laboratory; and N. Mori, professor of the Department of Industrial Design, Chiba University. They have their own speciality in the area of the application of composite materials to automobiles, ships, space aviation, and general products. Under committee chairman Mori they investigated image design.

Fuel Consumption May Become 34 Percent of the Current Figure

Their investigation and research covered the area from automobile design technology to material and element technology. They concluded that fuel consumption demanded for the third generation automobile should be less

than one half that of a present average for automobiles. This target could be realized not only by body structure, but also by the application of composite materials over each part of an under chassis, body assembly, and interiors. In addition, although the use of composite materials is presently limited, it is thought that its application could be realized because of an improvement in element technology in the future. The study investigates the present status of the application of composite materials to the automobile, the presentation of problems associated with lightweight technology and material property utilization of CFRP, and the introduction of a concept of an organic non-divided combination substance.

They also made a proposal with the possibility of realization concerning the method of decreasing air resistance, rotational resistance, and others, and showed the result indicating that fuel consumption would become 34 percent of the current figure. Finally, three proposals (A, B, and C) were given. Along with them, a car concept, hypothetic materials, specification, form characteristics, and various illustrations were shown. According to Professor Takehana, committee chairman, at this time, the proposals were made to indicate necessary research contents for composite materials in order to realize the third generation automobile. All subjects will require their detailed study, modification, and refinement from both the viewpoint of technology and value to society.

In order to investigate the technological possibility of applying composite materials to automobile body structures and then to manufacturing lightweight vehicles, it is necessary to match the property of style, functions, and economy as well as each element of technology with the value to society in the future. Otherwise, the realization of the project will not be seen. From this line of thinking, the study at this time was conducted. Based upon the investigation of the present generation and its trend regarding the application of composite materials, the following themes and targets were set up, and concrete design was presented.

[Themes]

(1) Under the assumption that the high-priced gasoline age may arrive by 2000, an expected passenger car design is proposed as three different concept designs.

(2) The fuel consumption of a current passenger car is targeted at one half current consumption.

[Targets]

(1) The realization of design is achieved without the restraints of present composite material technology already developed. Impetus is going to be given to necessary unsolved technology for its future development.

(2) An improvement in fuel consumption is going to be achieved not only by the development of a lightweight body, but also by a reduction in air resistance and rotational resistance, and lightweight and high performance

of an engine with the application of ceramics. In this occasion, unsolved technology at this moment is assumed to be realized by the year 2000.

Necessity To Break from the Conventional Concepts

Regarding the application of composite materials, most automobiles which have already been put to practical use or which have been developed as a prototype vehicle simply utilize composite materials without changing the fundamental form and structure of a vehicle. Rationalization along with the adjustment and unification of partial body structure is only seen in Fiat VSS and Volvo LCP 2000 as a trial base.

The application of FRP to the outer body panel of GM's Chevrolet Corvette since 1953, the use of SMC and R-RIM for the body outer panel of GM 1983 Pontiac Fiero, thermoplastics for the partial body outer panel of Honda 1983 CRX, and the use of SMC and ZMC for the hood and gate outer panel of Citroën 1982 BX are considered to be the practical use of composite materials. Recently, the application of various composite materials onto partial exterior or interior and exterior parts are anticipated for Japanese, American, and European automobiles.

As a prototype experimental vehicle, Ford applied CFRP to most parts of the body including a chassis of the lightweight concept car in 1977. However, the form and structure of the body itself was not changed. Fiat VSS 1982 Model and Volvo LCP 2000 1984 Model are vehicles which were structually studied. The former used thermoplastics for panels, but a steel-made frame was still in use as a primary structural material. Therefore, reduction in body weight was not much. That vehicle is rather characterized by the rationalization of assembly processes and the ease in making variations. The latter was designed from the original idea of part unification of which an upper body and panels made by composite materials were installed to an under body made of light metals. Therefore, a lightweight effect was achieved. Due to this, reduction by half in fuel consumption was achieved along with a direct injection turbo diesel engine. Presently, from an overall viewpoint, this car can be judged as the most advanced low fuel consumption experimental vehicle. Furthermore, a new trial is also seen in positioning of passengers. However, this car is still no better than the current concept in the field of form design.

Reduction by Half in Weight Targeted

The possibility of lightweight technology and the utilization of the property of CFRP are going to be considered. If steel plate parts of an automobile are replaced by CFRP, a remarkable lightweight effect could be seen. For example, in the case of Ford LTD 1979 model experimental car, a reduction by 60 percent in the weight of a basic body, hood, and doors was achieved. However, without modifying the structure, the simple replacement of a body steel plate by CFRP doesn't bring a good lightweight effect on a whole car body. This is because the weight of the body made by steel plates is only about 20 to 25 percent of that of the whole vehicle. Thus, in the case of this experimental vehicle, only a reduction by

30 percent in the gross weight was obtained by the active application of composite materials to the steel-made parts such as wheels and interior parts, and by the secondary lightweight technique, i.e., a reduction in the weight of the parts which became over designed due to the primary lightweight procedure.

In order to reduce the weight of a vehicle further, not only the utilization of composite materials and ceramics for an engine, driving device, and glass parts, but also the conclusive unification of parts are necessary. That is, by making the most of the merit of composite materials in easy forming, the integration of the frame of a body with panels, and the unification of ducts and seat frame with a body are carried out. In addition to these, the unification of window glass made by composite materials with a body, and the unification of the suspension system with a body are needed, although these are technically unknown and their concept is also still unexploited. If all the above are achieved, the gross weight of a vehicle would become half that of the present vehicle.

Change from One Part-One Function to Organic Combined Substance

As the prominent property of CFRP, it is possible to put anisotropy in strength and rigidity by controlling the direction of the composition of fibers, and also possible to make a spring having a good damping force by utilizing its elasticity. The following new design concept may be drawn by applying the above property.

The formation of a body is partially modified, and the composition of fibers is also gradually changed. As the result, the characteristics of the surrounding area of a specific portion are altered so that they correspond to the requirement of the behavior of a wheel's suspension. At the same time, it meets the requirement of the substitution for a spring and shock absorber. Since the composition of fibers has three-dimensional freedom, it is possible to distinguish the freedom of the form from that of the property to a certain extent. This is different from the nature of metals. Therefore, it may be possible to design corresponding to high-degree demand. If this technique is realized, a vehicle could be designed in which the number of "one part-one function" features as in the fundamental structure of a present vehicle disappears, and an organically unified substance which cannot be divided will appear.

Modification of Passenger Layout

Regarding a reduction in the air resistance of a car, the air resistance is proportional to a resistance coefficient and the frontal area. The technology to reduce the resistance has drastically advanced. The value of the order to 0.3 is well seen for practical vehicles. For example, for the case of AUTO-2000 project prototype car 1981 developed by West German automobile companies, the resistance was between 0.25 to 0.3. It was eventually less than 0.3. Without sacrificing practical functions such as interior space and visibility, it will be very difficult to reduce the coefficient less than 0.25 even though the continuous improvement of the form of a vehicle is going to be made. In order to break through this

difficulty, the conversion of the form including the layout of a vehicle is necessary. In this case, there will be the possibility of obtaining 0.2 to 0.25 by maintaining practical functions. The frontal area is influenced by outlines, height, and width. However, outlines and height of most of practical vehicles reach the practical limits. Regarding width, Mercedes-Benz recently shortened it by a small amount on W124. Except for this, generally speaking, no step has been taken. This is because the layout of passengers if fixed. This should be broken through by the modification of the passenger layout. For example, if 10 percent of width can be reduced, it may be possible to reduce the frontal area by 12 percent.

When a reduction in the rolling resistance is considered, the rolling resistance of a tire is mainly associated with energy loss at the inside of a tire due to repeated deformation by rotation. Frictional energy loss by sliding between a tire and the ground, and the air resistance of a tire count only 6 to 13 percent of the rolling resistance. In order to reduce energy loss at the inside of a tire, the optimization of tire structure, materials, cross section, and air pressure should take place along with riding comfort, handling, and safety. As factors being strongly related to a whole vehicle, not only lightweight body structure, but also an increase in the outside diameter of a tire are effective methods to reduce the rolling resistance. The assimilation of the increased diameter of a tire with the layout of a vehicle and form design seems to be one of the targets. A decrease by 30 percent with the performance improvement of a tire itself has already been made under the prototype base when compared with that of a current radial tire. A reduction by 65 percent may be possible with a reduction by half in the weight of a vehicle. Furthermore, if the positive effect brought by the increase of the diameter of a tire is taken into account, for example, the outside diameter becomes 1.3 times larger than the current one, a reduction by totally 73 percent can be expected.

Besides the above, making high efficiency of an engine, and the optimum control and the high efficiency of transmission system and supplemental devices are considered to be the methods to bring the possibility of an improvement in fuel consumption. If ceramics is applied to an engine, and exhausted heat recovery by the turbo-compound method is also utilized, a reduction by 13 percent in fuel consumption can be achieved even at the present time. This means that as the whole power plant system including the transmission system, an improvement by about 25 percent is considered to be not difficult to be achieved.

Trend of Technical Improvement of Fuel Consumption

When the possibility of the improvement of fuel consumption is considered, fuel consumption is influenced by the synthetic efficiency of an engine itself, the transmission system, supplemental devices, and the running resistance. The running resistance is categorized by 1) air resistance, 2) rolling resistance, and 3) acceleration resistance.

How much an improvement in fuel consumption can be carried out by making lightweight and other possible technical modification? (1) Under the assumption of which a 25 percent synthetic efficiency improvement is achieved by various items excluding an engine, in the case of constant performance, an output cut by making it lightweight brings a 20 percent effect to fuel consumption.

(2) Making lightweight--to reduce the weight of a vehicle by 50 percent.

(3) The reduction of the coefficient of the air resistance for the present average small sized passenger car is going to be made from 0.35 to 0.24, i.e., there is a reduction by about 30 percent. Regarding the frontal area, the area of the width of 1650-mm X the height of 1360-mm becomes 1500-mm X 1300-mm. This means that a decrease by a 10 percent of the area ends up with a decrease by a 12 percent of the actual frontal area. As the result, a reduction by 38 percent in the air resistance can be expected.

(4) Regarding the rolling resistance, a reduction by 65 percent can be expected without changing the outside diameter of a tire. If the diameter becomes 1.3 times larger, a reduction by 73 percent can be expected.

There are various data available for the ratio of the air resistance and the rolling resistance to the whole resistance at stable running condition. For example, at the running speed of 40 MPH, the air resistance is about 50 percent, and the rolling resistance is about 30 percent. As the acceleration resistance on the running mode including starting and stopping accounts for a large percent, the ratio of the air resistance and the rolling resistance to the whole resistance will decrease. With the combination of various running patterns, about one sixth of the rolling resistance contributes to the improvement of fuel consumption. In addition, since the acceleration resistance is proportional to the weight of a vehicle, the relation between the running mode and the weight is strong. A reduction by 40 percent in the weight improves fuel consumption only by 10 percent under 60 km/h constant speed running. But, a 28 percent improvement can be seen at the LA.4 Mode. If the intrim running pattern between the LA.4 Mode and constant speed running is named as the mixture mode, the half of the reduction rate of the weight contributes to fuel consumption. The ratio of the air resistance is considered to be about 33 percent for the case of no weight change, and about 46 percent for the case of the reduction of weight by half. Judging from these, it may be concluded that fuel consumption becomes one third that of the present small sized car for the case of a reduction in the weight of a vehicle by half. A contributory coefficient is 27 percent for lightweight and 37 percent for the items other than lightweight in the above consideration.

Three Different Typed Models

The following were taken into consideration when each concept (A, B, and C proposals) were drafted. With regard to the dimension of width, the number of passengers are three people plus one person (a couple and

two children, one of them is an infant). The width of a console box which is installed in an average small sized passenger car is cut short, and a left and right seat are closely placed. The width of a vehicle is reduced by 150-mm without shortening of the width of the seats. There is a good left front visibility for a driver. Front seats are placed by shifting each one. These are the common design conditions for each proposal.

Regarding the structure of a body, several proposals were considered. They are the structure integrated basically by two upper and lower parts, the united body structure including a window portion except a movable door portion, and the structure of which body panels have the function of a chassis or the structure of which a body panel frame has the function of a chassis when chassis parts such as a suspension and springs are incorporated in a body. The proposals were three different combinations of these ideas.

A wheel with a large diameter was adopted in one of the proposals. Regarding the layout of an engine and the power driving way, favorable methods were chosen without preconditions. Four-wheel steering by electronic control is installed.

[Proposal A]

This is a small sized passenger car of the FF type. Basically, the body structure integrated by two upper and lower parts is presented. The end of the lower structure possesses the gradual functions of a chassis. Special devices are added for an improvement in the aerodynamic characteristics.

Both the upper and lower parts are made by FRP with hybrid carbon and glass fibers. Especially, the density and the direction of fibers are continuously changed at the place equivalent to a chassis. Polycarbonate with silicate coating or the substitute for glass is used for a window. The dimension of a body is L;4000, H;1300, W;1500, and W/B;3100.

Aerodynamics of a body is characterized by an aggressive air stream from the lower portion of an engine compartment to a roof, and substantial lift control by winding up of the lower portion of a rear body end.

There are three side doors, two right doors, and one left door. An aerodynamic cover for a wheel is stable relative to the upward and downward movement of the wheel, and is jointly actioned along with the movement of steering.

[Proposal B]

A small sized passenger car of the FF type is basically proposed. It has the body structure integrated with a frame portion and a panel portion. The frame portion possesses the function of a roof and a chassis. The panel portion which constructs a compartment has skeletal suspended suspension structure, and a special aerodynamic device is added to it.

The materials used in this proposal are the same as for the Proposal A. The same dimension is used, i.e., W/B is 3180-mm. The aerodynamic characteristics can be described as the lift control by the upper air stream on an engine compartment and winding up of the lower portion of a rear body end. The same doors and the same aerodynamic cover for a wheel as used for the Proposal A are adopted.

[Proposal C]

A small sized car of the RR type is proposed. It has basically the integrated body structure including the window portion. The gradual chassis functions are placed at the end portion. A reduction in the rolling resistance by the use of a wheel of a larger diameter is targeted.

Regarding the materials, the body is formed by transparent resin (polycarbonate), and painting and colored film laminate are applied to all except the window portion. The density and direction of fibers such as carbon fibers are continuously changed in the chassis portion. This essentially satisfies the functions of a chassis. The dimensions are L;4300, H;1260, W;1500, and W/B;3360.

Avant-garde design under the idea of energy-saving is presented. There is one door of the lift-up type for front seats. Passengers are getting on and off the car through this door placed at the front. Steering is by electrical combination.

In connection with societal values and objectives, these proposals don't concern the wealthy who are uninterested in fuel economy. Among people who have middle-class consciousness and seek diversity, some will demand a high fuel efficient car even though the cost of that car is higher than the present one. Some will be also very interested in getting a car characterized by good fuel consumption and low cost when the price of gasoline goes higher than at present. These proposals are for people having middle-class consciousness and looking for diversity. A problem to be solved in the future is the feasibility study of the functions of a chassis which has been shown as technically new design concepts. It will be necessary to prepare a variation of proposed vehicles from the viewpoint of the consumer, and to establish the concept of low cost and ulta-small sized vehicle. Furthermore, in order to increase the possibility of realization, detailed study, modification, and refinement will also be needed.

20149/9604
CSO: 4306/3556

SCIENCE AND TECHNOLOGY POLICY

JAPAN, PRC TECHNICAL COOPERATION DISCUSSED

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENTIOLOGY AND MANAGEMENT OF S&T] in Chinese No 2, 1986 pp 4-6

[Article by Masaru Saito, professor, Chuo University, Japan: "On Technical Cooperation between Japan and China"]

[Text] I. Chinese Technological Strategy

At present, China is heavily engaged in the development of the focal point of its four modernizations. In its strategy to introduce foreign capital, China has strenuously studied the experience of other countries and adopted policies most favorable to China such as various policies about modernization, advanced industrial systems, and management and technology transfers which have nearly all been adopted. However, the focal points are still on the following aspects: 1) transplanting new industries; 2) strengthening management and technology transfers; and 3) doing its best to acquire better results for the four modernizations.

At present, China is trying, through various ways and means, to achieve technology transfers from foreign countries which concentrate not only on the "hardware" but on the "software" as well; they are not only introducing engineering technology but are also interested in the technology of management. They have corrected their shortcoming in the past of looking down on management and are striving to introduce enterprise management from the developed countries under the economic conditions of the free market.

From now on, the focal points of the Chinese technological strategy are: 1) to strive for the development and application of advanced technology in order to serve important areas of national construction. 2) To strengthen technological innovation and create a better structure for industry. 3) To strengthen the introduction, development, and computer technology. 4) To hasten the reform of economic and technology systems and their internationalization. 5) Considering the stage of technological development in China, technology transfers in addition to development based on self-reliance, are still crucial. The really necessary "four transfers" advocated by the Chinese government, which include science and technology transfers, must be carried out from foreign countries to China, from military to civil application, from coastal areas toward the inland, and from

laboratories to the site of production. However, there exist many problems in their realization. 6) In order to put the transferred technology into production, cultivation of talent is also one of the strategies adopted by China at present.

II. Structure of Technology Transfer

In the past few years, the Chinese technology transfer market has been expanding rapidly and according to various patterns. In addition to trade, foreign investment, and technology cooperation, various routes of technology transfer have been opened. For example, the number of technology delegations and the people sent abroad for long- and short-term study increases year after year and this increase has occurred on a nongovernmental basis.

Now, there are graduate students in the big, medium-size, and small enterprises in Japan, and among the countries which have technological cooperation with Japan, China has the greatest participation.

China has introduced a great number of complete sets of equipment, such as complete sets of chemical engineering equipment in Shanghai, Zhejiang, and Tianjin; complete sets of thin-film manufacturing equipment in Gansu, Shanghai, and Tianjin; and complete sets of television set manufacturing equipment. In the technology trade in 1983, Japan has 41 percent of the total amount of the technology introduced into China, the United States has 30 percent, West Germany 9.5 percent, and Italy 6.5 percent.

The characteristics of the market of introducing technology into China are these: 1) speaking in terms of region, the large cities are the focal points and most of the technology introduced is concentrated in Shanghai, Tianjin, Beijing, and the Shenzhen Special Economic Zone; 2) in technology introduction, expenditures on "software" are mounting; and 3) the demand for high technology is increasing.

In addition, various kinds of high technology have been introduced through trade. It is said that the list of the Chinese delegations shopping for technical equipment abroad also includes: 1) satellite navigation systems; 2) tracking radar and laser range finders; 3) night vision equipment; 4) military vehicle simulators; 5) giant lathes for large-caliber cannons; and 7) though the introduction of technology for medium-size and small enterprises is vigorously advocated, the proportion of introduction into large enterprises and military technology has been greatest.

In addition to licensing, China has also introduced a large amount of technology through the purchase of machinery and complete sets of equipment. The major countries exporting technology in China in 1983 are Japan (25.9 percent, occupying first place), the United States (13.0 percent), Hong Kong (8.0 percent), Canada (7.5 percent), and East Germany (5.7 percent). From now on, Japan and the United States may become the center, and the introduction of technology from the developed Western countries will increase with the emphasis on introducing industrial technology from Japan and military and aircraft-related technology from the United States.

Japan ocupies the first place in almost every aspect of technology transfer to China. In particular, Japan has accepted a great number of Chinese graduates majoring in various areas of technology. Even as analysis of the history of technology transfer to China up until now would produce the conclusion that China is in the climax of technology introduction.

Technology transfer from Japan has involved a wide range of technology in agriculture, and also other areas, such as industrial measuring-instrument technology, special natural gas valve manufacturing technology, electron microscope manufacturing technology, air compressor manufacturing technology, and industrial sewing machines. Medium-size and small enterprise technology introduction has also increased rapidly.

Looking at strategy, technology transfer requires the mutual efforts of technical personnel from both sides and that requires a better mutual understanding.

III. Strategies of Technology Introduction

The strategy of technology introduction in China is first to make choices in technology based on the overall strategy and then to introduce certain technologies according to the plan. The characteristics of Chinese strategy in the introduction of technology related to people's livelihood are to attract technology to the country and to wait for the opportunity of international technology exhibitions to bring the practical technology into China after the acquisition of all the information, after which the discussions and transactions will proceed. The key to the discussions and the conclusion of transactions is completely determined by negotiations, and there is a substantial difference compared with practices in the developed capitalist countries.

In the procedure of technology introduction, China has first chosen urgently needed suitable technology and has carried out discussions with the companies related to that technology transfer. China also attracted tangible technology into the country through international technology exhibitions. In the discussion and the conclusion of transactions, the Chinese usually adopt a triangular negotiation pattern, which means to negotiate with both the company from which the technology is expected to be transferred and some other foriegn company, that is, to open discussions among the foreign enterprises transferring that technology. The discussion item by item and category by category and the parts which can be locally manufactured are excluded from the discussion. People who attend the discussions are technical experts, experts in commercial affairs, financial experts, and legal experts, and through the coordination of these experts, they attack on many levels to increase their negotiating strength.

The experts on commercial affairs and the legal experts have carefully studied the "Charter of Activiites on Technology Transfer" of the United Nations and

they are masters of the laws of industrial ownership. In the last few years, Chinese professional teaching materials on technology introduction have increased day by day.

According to the regulation of the policy published in 1979, articles which can be manufactured in the country will not be introduced regardless of price. In the introduction of complete sets of equipment, those which can be manufactured in China must be excluded; redundancy must be avoided; and the countries or enterprises will be chosen where parts, components, and raw and processed materials can be reasonably supplied. The stipulation mentioned above is a technology introduction policy based on technology transfer, and that technology transfer will in the long run be beneficial to the vigorous development of the country.

Technology introduction, in addition to patents, also includes the introduction of new mechanical equipment and foreign companies can proceed in the manner of investment. Therefore, these points can also be taken into consideration.

IV. Sino-Japanese Technological Cooperation

China, before the implementation of the open-door policy, received little economic and technolog cooperation from the West. The acceptance of cooperation without compensation began in 1981. Cooperation with compensation for the sake of realizing the open-door policy cannot be expanded without considering the ability to pay. The value of technological cooperation reached its climax in 1981; since then the change has been small. In general in cooperation without compensation, a big project is the Sino-Japanese hospital (completed in 1984). In addition, the construction work on the Beijing Post and Telecommunications Training Center and on the Chinese Meat Foods Multiple-research Center is continuing. The focal ponts in cooperation with compensation are items of basic construction such as railroads, harbors and dams, and telephones.

In technological cooperation, the number of graduate students and professionals sent abroad and the number of engineering projects involving technological cooperation are increasing rapidly. Of the foreign countries helped by Japan, China has been number one since 1982; however, counting in terms of the average population helped by Japan, China is still last.

The developed countries entered the Chinese market through the centers of coastal cities such as Beijing, Tianjin, Shanghai, and Guangzhou. Manchuria is the place of principal resources and an area of heavy industry in the north, though the developed countries felt that the level of technological cooperation there was not enough.

China has been emphasizing agriculture. Therefore, it has achieved very good results in the development of agriculture. In industry, China as well as other socialist countries stressed the development of heavy industry. Thus the development of light industry and medium-size and small enterprises slowed. At present, China is striving for the development of medium-size and

small enterprises and their modernization to maintain the development of heavy industry, strengthen the flexibility and adaptability of the national economy, and stimulate the vitality of the enterprises.

V. Problems of Technological Cooperation

China is a socialist nation. Therefore, both the selection of the graduate students sent abroad and their work assignments can be done according to the plan. The medium-size and small enterprises in Japan accept a great number of graduage students each year but provide mainly on-the-job-training and are not professional training organizations. The students work very hard, yet the results of their study are low. Since there are more than 20,000 Chinese graudate students sent to our country each year, we had better adopt a more systematic method to do it. And this is consistent with the direction of "education cooperation" flourishing in Japan.

China is walking along the road of socialism, and maintaining independence, and keeping the initiative in its own hands, which contrasts sharply to the capitalist market of free competition. Though it uses the same techniques, the function and meaning are different. Nevertheless, even the technology from capitalist societies can contribute to the development of socialism. The developed countries in the West and East have blocked technology transfers to the Eastern countries in the name of "Coordinating Committee for Export to Communist Areas." This has been relaxed to a great extent to China in the past few years, yet it has not been abolished and may become strict again.

Chinese patent law was implemented in April 1985. To introduce advanced technology, patent rights must be acknowledged and the technology rightly protected. Proper implementation and observation of the law have a direct influence on the international prestige of a country. As for the suppliers of technology, if the technology is not protected under the law, they will no longer transfer their technology. Whether the Chinese are able to enforce the patent law correctly to provide sufficient protection to the rights of the technology suppliers is one of their great tasks. We can also say that the above understanding will apply the same to the foreign investment law, corporate law, and commercial trade law under formulation now.

In the following article, we will talk about the relation between the "four modernizations" advocated by the Chinese and Sino-Japanese technological cooperation. Military and national defense modernization is included in the four modernizations. For some reasons, Japanese technology cannot cooperate in every aspect of the four modernizations.

Finally, I think that all the developed countries, including Japan, seem to compete for cooperation in the technology transfers to China, yet it is not clear at present whether the introduction of technology into China is for the development of Chinese socialism, which is introverted, or for the joining international (export) competition, which is extroverted. Even if Chinese technology introduction is extroverted, it may not for the developed countries end up in eating one's own bitter fruit (Chinse version [Japanese to Chinese translator's note: that is, the possibility of China's becoming a developed

country and competitor), owing to the huge gap in the levels of technology between China and the developed countries, but to the NIC's in Asia and the countries of Southeast Asia, China is very likely to become a competitor. For industrial products of equal quality, especially the production of labor-intensive products, once export becomes possible, their impact on the large countries will be enormous. In case the coordination of shared production ([Japanese to Chinese] translator's note: that is, different countries produce different products) cannot proceed smoothly, it is very likely that trade conflicts will occur between China and the Asian NIC's and the countries in Southeast Asia. If the current Chinese open-door policy continues as it has, in the 1990's Chinese exports of industrial products will increase rapidly.

To solve the above problems and then maintain and accelerate the development in Asia to contribute to the peace of the world, it is necessary to establish, through Chinese economic development and her joining the shared production structure, a healthy interdependent relationship at least in Asia. And Japanese technology transfers must proceed in line with the contribution to that relationship.

12909/13104
CSO: 4008/2086

SCIENCE AND TECHNOLOGY POLICY

NECESSARY CONDITIONS FOR JOINT VENTURES WITH PRC

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENTIOLOGY AND MANAGEMENT OF S&T] in Chinese No 2, 1986 pp 6-7

[Article by Keizo Umeda, Himeji Junior College, Hyogo Prefecture, Japan; rewritten by Yong Qian [0516 3677], Zhao Beiwang [6392 054 2598], chief editor: "Necessary Conditions for Joint Ventures"]

[Text] In a world where science and technology progress day by day, it is rather difficult to be outstanding among other competitors; therefore, every enterprise tries to change the structure of its industry and technology and consolidate its position through joint ventures.

However, there are also lots of examples of termination of an agreement of cooperation among the developed countries. At present, the conflicts are acute. In general, joint ventures have the following problems:

1. The items of joint-venture enterprise are more mature, so the introducing country loses the characteristics of being a new producer and also loses the true significance of joint ventures. Thus a joint-venture enterprise can be banned easily by the mother company.

2. Owing to the recession of joint-venture enterprises, their strategies of management must change; otherwise the result will be that the investor country cuts its investment and limits it to a small amount of capital or recalls its total investment. Consequently, the other party revokes the administrative power of the investor.

3. The elimination of obstacles to both parties on the basis of mutual understanding and mutual trust between the two partners not only in appearance and formality but also in an honest and sincere exchange of opinions and management.

4. In case difficulties or problems in management emerge in the mother company, the contract is cancelled and the enterprise is managed independently by a single party.

Therefore, it is necessary to summarize conscientiously the causes of failure of joint-venture enterprises and pursue the ways and means of success and improvement.

Sources from multinational enterprises in Europe and Japanese enterprises abroad reveal that the causes of failure of joint-venture enterprises can be summed up as follows: incomplete market research and inadequate investigation within the enterprise, poor management by the mother company, and a change in foreign investment from the mother company.

The causes of failure from the local society include inconsistency of opinions with the [mother?] company and external causes, mainly from an economy that is overproducing. To avoid the above-mentioned occurrences, the key is to maintain harmony with the local enterprises and collect information from the client countries to become mutually prepared; select the places for local investment, analyze the characteristics of the products and the competitive situation, predict the buying power of the joint-venture enterprise, and determine the purchasing price, conditions, and commercial customs, according to the size of the market; and analyze, through the cycle and according to the cost of transportation, the conditions for production equipment, materials, regulations about the social effects of pollution, and labor in order to explore the productivity of the enterprise, the tax system, capital transfers, and the budget. The most important among the conditions mentioned above is how to make a selection. It affects whether the enterprise can be successful or not. Besides, it is necessary to study further the culture and history of the host country in order to communicate for the joint-venture enterprise and eliminate misunderstandings. Also attention must be paid to the distribution of authority. It is necessary to conduct technology transfers and develop new technology on a broad scope from manufacturing and processing to management.

In technology transfers, it is important to introduce new technology; however, it is even more important to develop new technology. If new technology is developed, there will be room in both the developed and the developing countries for technology transfers. Modern multinational enterprises do not rely on capital or ownership but pay attention to the distribution of production in order to enhance the cooperation between East and West.

Nevertheless, the essence of joint-venture enterprises is to enable the partners to draw on the strengths of each to offset the weaknesses of the other to maintain the cooperative system. Once mutual trust is established among the partners, it is necessary to overcome any difficulties; otherwise, that organization is bound to collapse, no matter what it is. This is what we should always remember.

But in the past few years, the international investment environment has changed and some new problems need to be solved urgently. As we saw in Iran, even in a so-called stable market and host country, with revolution, internal disorder, and war and with the ending danger of a termination of the projects in progress and a takeover of capital before fulfillment of the contract, the future situation can be hard to imagine. Countries with an accumulated debt include most developing countries striving to carry out their economic

policies but these countries are still thought to be the most promising countries as host countries for investment. However, because of the accumulated debts, the profit received by the host country is greatly limited and, as a result, the reinvestment of that profit in the host country by the investor is limited.

Thus, there are strategic measures such as the signing of an investment protection agreement between the investor and host countries in order to lessen or minimize the investment danger.

In China there are in general many achievements in the acceptance of foreign investment, but the following problems still exist: 1) there is more cooperation based on an agreement but few on joint venture; 2) more capital comes from Hong Kong and Macao compatriots and little comes from foreign enterprises, or consortiums; 3) there are more medium-size and small items but few large ones; 4) there is more investments in tertiary industries but little in manufacture for export; 5) in intended investments which have been revealed, there are more items which require longer terms of negotiation while few eventually arrive at a satisfactory conclusion; 6) the amount of investment stipulated in the contract is high while the actual investment is low; 7) more foreign investment is introducted but foriegn exchange created with the foreign investment is little.

In joint-venture enterprises with investment from Japan, from basic enterprises to enterprises representing a great volume of trade, and if underwater operations are included, along with the increase in the number of joint-venture enterprises, the kinds of the enterprises have also expanded in many aspects, from the servicing and manufacture of motors or generators and fiber products to the manufacture of automobiles.

The reasons for the rapid growth in Sino-Japanese joint ventures are, first, because China has made great efforts to expand favorable treatment and enhance the law. However, the problems caused by the increase of joint-venture enterprises have become cleared. The main problems are the following: now, in the joint venture, the most troublesome thing for the Japanese party is the pricing of land and the second is the insufficiency of transportation at the harbors, which affects exports. Therefore, the harbors need to be reorganized and enhanced and new ones built. Third, people do not quite trust the supply of energy and raw materials. Though the supply of energy and raw materials for joint-venture enterprises has priority, severe energy shortages in the country exist, especially in electricity, and when joint-venture enterprises increase later on, the stable supply of electricity in some places may experience some difficulties. Fourth, the sovereignty of labor enterprises, yet the enterprises can only recruit workers in the suburbs; they hope to recruit the finest workers in an wider area but there exist difficulties in applications for residence in the municipalities. Furthermore, wages tend to rise, especially when there is a shortage of people who can speak foreign languages, and their wage increases have been great. Besides, there are some problems in labor control. In the establishment of some joint enterprises, some managers think they must fully realize the meaning of the existence of the labor union. The fifth problem relates to the regulations about the

distribution of foreign exchange and the strengthening of the obligations to export. Owing to the strict control policy over foreign exchange, joint-ventures enterprises or those based on technological cooperation with foreign countreis worry about their production being caught up in difficulties, and so foreign exchange capital must be positively suppled for the importation of advanced foreign technology by local export industries. If foreign exchange capital becomes more flexible and accommodating, the foreign exchange control will be relaxed a little, and thus the obligation to export for the joint enterprises will be strengthened. Sixth, along with the progress of technology transfer, some disputes over the expense of technology transfer will arise. In the introduction of foreign advanced technology, some Chinese in charge do not know about paying technology consulting fees, fees for using others' patents, and deposits for security. For example, the unwillingness to acknowledge the value of some technologies is the biggest stumbling block in the trade for foreign enterprises to transfer technology to China. In the future, in the cooperation between China and foreign countries, if China does not acknowledge "technology fees," the work of introducing advanced technology will not be able to proceed smoothly. The seventh problem is the restriction of investment proportions in joint enterprises. China has strict restrictions on the number of enterprises that have foreign capital in the majority, which is contradictory to the regulations of joint-venture enterprises. The final important thing is the terms of the joint enterprise. The Japanese enterprises hope that the term designated by the current regulations will be extended appropriately.

12909/13104
CSO: 4008/2086

SCIENCE AND TECHNOLOGY POLICY

FUTURE OF TECHNOLOGY, INTERNATIONAL COOPERATION DISCUSSED

Tokyo KOGYO GIJUTSU in Japanese Feb 86 pp 9-19

[Text] The Agency for Industrial Science and Technology, in order to explore technology in the future and the best means to carry out international exchange with regard to that subject, established, in September 1985, as a consultative body of the Director General of the Agency of Industrial Science and Technology, a "Study Group on Technology and International Exchange." This group, chaired by Yoshikazu Ishisaka, consultant to the Nomura Comprehensive Research Institute, has held four meetings.

We have put together the interim judgments of this study group and have decided to offer them to other groups for debate. The contents are presented below.

1. Tasks on the road to the 21st Century and the Role of Science and Technology

(1) Prospects for the 21st Century--Origin of the Technological Revolution and the Role of Science and Technology

The rapid pace of science and technology since the middle of this century has brought about unprecedented prosperity for a majority of the human beings of the world. In other words, the world economy has achieved the high growth rate of 5 percent per year between 1950 and 1973. The rate of growth in the population was 1.9 percent for this period, and the gross productivity growth rate per person was over 3.0 percent. On the average, per capita income doubled during this period. (See Table 1)

When we reflect on the long course of human society from the prosperity of the modern era, we can see that new industrial technology greatly changed the times. In the past, the transformation from primitive society to agricultural society by the acquisition of agricultural technology and the industrial revolution, which occurred in Great Britain from the latter half of the 18th Century to 1830, were preludes to the industrial society that has continued up to modern times. Industrial technologies such as the steam engine, cotton gin, the boring machine, a soda manufacturing method, and cement were the products of this era. We can call this era the first technological revolution.

Furthermore, from the latter half of the 19th Century into the 20th Century, many new industrial technologies emerged one after another, especially in the

Table 1. World Economic Growth and Increase in Population (1950-1983)

	Growth Rate of GWP (%)	Growth Rate of Population (%)	Per Capita Growth Rate of GWP (%)
1950-73	5.0	1.9	3.1
1973-79	3.5	1.8	1.7
1979-83	1.7	1.7	0.0

(Source): GWP (Gross World Product) is in "The Product in 1980" (Washington, D.C.: U.S. Department of State, 1981) and the estimates of the World Institute.

Population is based on United Nations data and the estimates of the World Institute.

Table 2. Forecast of World Population (Unit: 1,000 people)

	World	Advanced Countries	Developing Countries
1985	4,842,148	1,172,863	3,669,185
2000	6,127.117	1,275,655	4,851,462
2010	6,994,741	1,330,262	5,664,479
2025	8,177,052	1,396,673	6,780,379

(Source): Median estimate of the 1982 United Nations estimate.

(Note): Advanced countries means Japan, the United States, Canada, all of Europe, Australia, New Zealand, and the Soviet Union. Developing countries means the rest of the world.

United States, for example, the converter (revolving furnace) method of steel manufacture, wireless communications, the automobile, the diesel engine, the telephone, the phonograph, the incandescent lightbulb, and the airplane. This can be called the second technological revolution.

The period from 1925 to 1950, when technologies were developed whose benefits we continue to receive today, can be called the third technological revolution. For example, the technologies developed included the computer, commercial television, the rocket engine, nuclear energy, radar, synthetic rubber, nylon, and polyethylene.

In this way, the technological revolution shaped the new industrial society. That industrial society, along with technological progress, has produced a wide variety of needs which have led to new technological innovations that, on their own, follow a pattern of infancy, growth, and maturity. For example, the practical uses of a calculator produced the need for miniaturization of the calculating element and rapid calculation. That was tied to the development of the transistor and the development of high speed elements. In other words, the technological revolution and the shape of industrial society can be said to grow side-by-side, each absorbing and expanding on the achievements of the other.

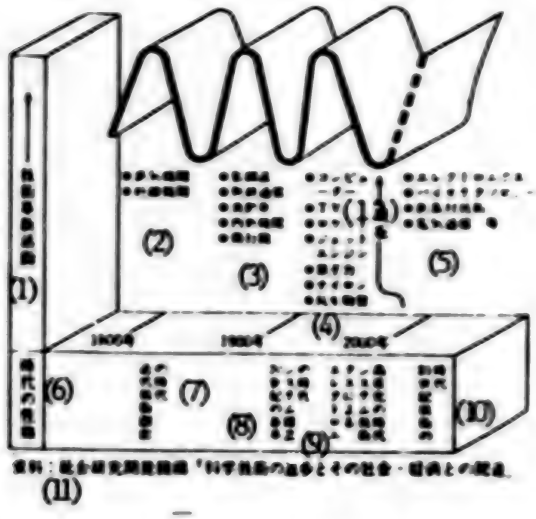
The current era can be considered a formative era of great technological advances leading to the 21st Century. As everyone knows, revolutionary industrial technologies, including electronics, new materials, biotechnology, and information processing and communications have emerged one after another. (See Figure 1)

On the other hand, if we take a long-term look at the world of the 21st Century, we can expect an environment of a shape different from the past. The first of these expectations is that the increase in the world's population will have a great impact on the world's politics, economy, natural resources and energy, and food. According to an estimate of the United Nations (1982), the world's population will increase from 4.8 billion people in 1985 to more than 6.1 billion in 2000, and approach 8.2 billion in 2025. (See Table 2) Over 90 percent of the increased population during this period will be located in the developing countries. A common task of humankind, then, will be to maintain the standard of living during this population increase and to raise the income of the people of the developing countries which is presently at a low level.

The second expectation is coping with the aging of the population and the maturation of society which will be most notable in the advanced countries. We can expect a change in the traditional form of labor which concentrated on labor by industrious and healthy youths and adults. Maintaining the vitality of our economic society during this change will be a task.

A third expectation is the establishment of a new relationship between science and technology and people. Since the beginning of the latter half of the 20th Century, the relationship between mechanical systems and people, and information systems and people, such as the spread of electric household appliances, the increase of privately owned automobiles, the introduction of automation in factories, the advance of a high information society including OA (office automation) and HA (home automation), has grown stronger with each passing year.

Figure 1. Waves of Technological Innovation



Key:

1. Technological innovation activity
2. -Steam engine
   -Spinning machinery
3. -Steel methodology
   -Wireless communications
   -Automobile
   -Internal combustion engine
   -Airplane
4. -Computer
   -TV
   -Rockets
   -Jet engines
   -Nuclear energy
   -Nylon
   -Antibiotics
5. -Electronics
   -Biotechnology
   -New materials technology
   -Telecommunications
6. Nature of the age
7. Age of origins of modern technology
8. Age of 20th Century basic systems establishment
9. Age of high quality systems technology by means of electronics
10. Age of 21st Century technology
11. Data: Comprehensive Research and Development Institute's "Progress of Science and Technology and Its Connection with Society and the Economy"
12. Today

Moreover, special properties are required to increase the reliability of the systems accompanying the huge growth of the social system. These include the decentralization and self-regulation of systems. Needless to say, such technologies improve productivity and make our lives wealthier, but there is concern about the possibility that the expansion of the interface of mechanical systems and information systems with humans will cause an expansion of a human psychological burden that may be called "techno-stress." A task accompanying this process occurs is to establish a relationship between science and technology and human beings that will not alienate humans.

In order to tie together these tasks of the era leading up to the 21st Century and the technological revolution, and to follow a course of friendly and mutual growth, we need to look at the current situation wherein technology, in comparison with the past, is markedly more complex and sophisticated, and to search for a new great breakthrough.

Industrial technology is the force behind economic development in any era, and is the key to creating a wealthier society and new culture and civilization. In order to sustain a world that is wealthier and full of energy in the next generation, we need to overcome the variety of problems that inhibit growth and to seek a path designed to achieve harmony between technology and human beings. We inevitably expect that the role of building this road to a wealthier society will be given to the emergence of new industrial technology. History clearly indicates that the emergence of an industrial technology to construct this new era requires activities connected with broad and basic science and with technology that will lead to the breakthrough that will nurture the buds of this new industrial technology.

(2) Tasks Leading to the 21st Century and Needs of Technology

Heading towards the 21st Century, we have a variety of tasks to overcome. Within these tasks are many problems to be resolved by social and institutional approaches, such as the reallocation of social resources and institutional reforms. However, to resolve many of these problems, we need the fruits of technological development to break through the limits of the social and institutional approaches.

Moreover, the technological approaches required are not merely the improvement and betterment of existing technology. Rather, we need to start dealing with this from the basic research stage. This includes the creation of a technological structure to support industrial society by returning to the scientific bases for physics and phenomena.

Moreover, in light of the nature of the tasks that we must overcome as we head towards the 21st Century, we need to bear in mind the following two points when carrying out research and development.

First, we need to deal with this issue from a global perspective. This is because, in our current state of increasing international mutual interdependence, the problems of natural resources and energy, and population, which we confront, are problems that already are not just of one nation or region but are those which essentially transcend national borders.

Second, the advancement of research and development is indispensable to the dignity, mental state, and life of human beings. While technology provides benefits to humans through progress, it also threatens, both directly and indirectly, our very health. Moreover, since the industrial revolution, technology has greatly changed the mode of our labor and, furthermore, has continued to have all kinds of effects on our everyday domestic lives. In the future, the relationship between the mechanical systems and information systems accompanying the high information society and human beings will keep increasing. This will require us to pay full attention to the adverse effects this has on the spirit and the mind, which are known as "techno-stress."

When we consider, from the tasks of the 21st Century, the special characteristics required of the technology of the 21st Century, the first which ought to be brought up is "energy burden reduction" technology, which keeps in mind the guarantee of a stable supply of energy and energy conservation. In Japan, the degree of dependence on oil has declined from its 1973 peak because of both public and private efforts carried out because of the two oil crises. However, Japan's degree of dependence is still the highest among the advanced countries. When we consider that our need for energy will continue to increase in the future to maintain perpetual growth of the economy, we need to study energy conservation, the development of alternative energy sources, and the reuse of resources.

The second special characteristic to be sought of the technology of the 21st Century is "environment burden reduction" technology. The problem of damage to the global environment is a problem that we ourselves are beginning to see as a problem close to home. Once the global environment is lost, it will be virtually impossible to bring it back to the current condition. We are liable to lock out great unknown possibilities.

Third, there is "decentralization" technology. In order to increase the reliability and safety of systems which tend to become huge in size, and to guarantee security, there is a need to introduce the concept of decentralized control within large systems.

Fourth, there is "self-regulated function (self-adjustment and repair function)" technology. The increasing size and complexity of systems is causing an increase in the maintenance costs of systems. Social systems and mechanical systems, which build in self-adjustment and self-maintenance functions, will probably play a role in the increase of reliability and reduction of maintenance costs.

Fifth, there is "human-machine fusion" technology. The realization of the man-machine interface, which, on the basis of a knowledge of human engineering, can lighten the psychological and material burdens of humans, will contribute greatly to expanding new regions of human intellectual activity.

(3) Where will We Look for the Breakthrough in Technology?

(a) The Swell of the Technological Revolution Towards the 21st Century

The swell of the technological revolution towards the 21st Century is expected to develop rapidly in various fields, such as microelectronics, new materials, biotechnology, and information processing and communications.

The 11th report of the Science and Technology Council offers three characteristic directions of the development of science and technology in recent years: the "progress of miniaturization and high functionalization of science and technology," the shift from hard core science and technology to science and technology with an increased weight on soft areas, such as increasing intelligence, and "a general meeting" and "strengthening of the close relationship between science and technology and human beings." The orientation of the great swell of the revolution of industrial technology truly matches this sort of orientation. In other words, the fields of electronics, new materials, and biotechnology are all pursuing miniaturization and high functionalization at the molecular level by aiming for a world of super-microelectronics. Moreover, one example of this is the increasing weight given to software within the technological system which supports the high information society.

Nevertheless, looking over the ultra long-term, the key opportunity to bring about a breakthrough in the extreme limits of innovation of industrial technology following this orientation is expected to arise in the fusion of advanced technologies. Looking at the level of basic science supporting these technological systems, it is often said that new developments in the area of fusion of natural sciences such as physics and chemistry and biology-related natural sciences will lead innovation in future industrial technology.

When we reflect on the development of industrial technology in recent times, we basically find that, based on progress in physics and chemistry, industrial technology has achieved innovation. The development of the organic synthetic chemical industry and telecommunications technology from the 19th to the 20th Century, and the technological development of electronics and nuclear energy in this century, are truly examples of that. Both became forces that greatly changed the structure of industry. Consequently, in the modern era, we feel that great revolutions will continue to occur in biology and related technologies by supporting the progress of chemistry and physics. (One example of this is the "DNA double helix model," which was announced by the American biologist Watson and the English biologist Crick in 1953, and the "Genetic Recambinant Experiment" which Americans Cohen and Boyer carried out in 1973.)

When forecasting the industrial society of the 21st Century, the necessary wellspring of innovation of industrial technology will be preparation by basic research today and the discovery of new theories. When one considers the time lag from the discovery of new theories to the completion of an industrial technology, we need to begin tackling this problem right now.

(b) Biofunctional Engineering as a Fusion Point of the Realm of Study and Practicality--Learning the Wisdom of the Creator (Biofunctional Applied Technology)

A living body is composed of countless elements and is a functional assemblage of extremely delicate and miniature functions of many sorts, such as the physical functions of digestion, movement, immunity, and self healing, and the mental functions of knowledge, memory, judgment, emotion, and desire. The points we need to study are also many. Biofunctional applied technology is a technology system that analyzes the superior functions possessed by the body and aims to engineer these functions by imitating them or obtaining hints from

them. In working towards the development of biofunctional applied technology, it is indispensable to have full progress by related scientific technologies such as materials science and electronics. Conversely, the progress of biofunctional applied technology is expected to be an opportunity for remarkable progress of related technologies. In that sense, biofunctional applied technology is a field with an extremely broad base.

Biofunctional applied technology is a technological field whose borders extend across advanced technologies such as electronics, new materials, and biotechnology. In light of the tasks and needs for the 21st Century, this is a realm where a major technological breakthrough is expected in the future and is a realm that conceals many possibilities and is a treasury of seeds [potential]. The two points below represent why there are expectations for biofunctional applied technology.

First, biofunctional applied technology has the latent possibility of being a force behind a society and industrial structure that consumes less natural resources and energy and is independent of fossil fuels. At present, the development and introduction of new energy is proceeding positively, but it is necessary over the ultra long-term to change drastically and structurally a society and industrial structure that heavily consumes resources and energy and is dependent on fossil fuels. Petrochemical resources, beginning with oil, are not only energy resources; they are used as major raw materials to support the modern chemical industry. Therefore, along with the development of alternate energy resources, there is a need for the chemical industry, which concentrates on fossil fuel resources such as oil, to proceed with an alteration and diversification of raw materials. Biomedical chemistry is believed to be one key to opening the door to the non-oil era in the chemical industry.

Moreover, power systems that center on internal combustion engines, beginning with automobile engines, need to be freed from oil dependence. At present, the conversion to synthetic fuels such as alcohol is proceeding, as is the development of the electric automobile, but this is not a substitute since much energy is still consumed. In this area as well, there is the possibility that a completely new power system will emerge (bioengines and biomotors), based on imitation of the highly efficient and non-pollutant functions of the living body.

In the second place, biofunctional applied technology may be able to achieve a technological system desirable for human beings. In other words, if we consider physics, we may be able to minimize the burden on the environment in the energy area by forming an ecosystem that fully makes use of solar energy. Moreover, in the psychological area, if an information processing structure and system can be realized that easily imitates the operations of human beings by imitating the functional framework of the brain and the nervous system, this will contribute greatly to harmony between machines and human beings.

(4) The Origins of the New Technology Being Sought Especially in Japan

The tasks of the 21st Century, which were stated from a worldwide perspective in the foregoing section, are virtually all applicable to Japan. The aging of the population in Japan is expected to move into the 21st Century at a speed unlike that of any other country. Moreover, the needs of the nation during

maturation of the economic society will diversify and the task into the 21st Century will be to realize an industrial structure to meet this challenge. Moreover, the position that Japan holds in the world economy is rising, and Japan seeks to make a proportionate contribution to international society as stated in a later section.

In this way, continued economic growth is a major task for Japan into the 21st Century. The conditions in which it is placed, which appear in the extreme, namely, being a narrow country and one scarce in resources, will, of course, increase and be severe for the nation because of the level of production activity and the size of the resource demand. The key to overcoming these constraints and achieving the postwar economic growth was an industrial technology that moved along a high road without interruption, and, in the international society of the future as well, we need to maintain and develop this high level of production technology. The level of industrial technology of our country in the past was maintained and developed by the introduction of technology from Europe and the United States and by the development of applications. However, the overall situation indicates that we cannot expect to follow this past pattern in the future. Our greatest task is to become "a technological power" by the development of our own technology.

2. Importance of International Research Cooperation in the Creative Research and Development by Universities and Business

(1) The Enlargement and Complexity of Research and Development Themes

In the development of the latest high technology, research concerning the structure of matter and genes on an atomic and molecular level, research going back to basics such as research into the properties of matter under extremely low temperatures or super high pressure, and complex research transcending existing areas of research, such as biofunctional applied technology, mechatronics, and medical engineering, are all necessary. As a result, this has brought about the increased complexity of the contents of technology and the broadening of fields. The need is increasing for human and capital research and development resources to accompany this, and if a slowdown of future world economic growth is expected, fields will increase where the funds and human capital of one nation alone will be insufficient.

For example, in Europe, in addition to existing international research and development organizations such as CERN (European Community Nuclear Energy Researcy Organization), whose aim is the research of particles, and ESA (European Space Agency), whose aim is space development, the Eureka Project advocated by French President Mitterrand was launched this past April. Moreover, in the United States, the decision has been made to promote, through international cooperation, the Strategic Defense Initiative (SDI), which is essentially made up of high technology development in electronics and communication. In these ways, international research and cooperation appear to be increasing greatly.

(2) The Necessity of Human Exchange and Information Exchange

Research and development is one of the most creative of human activities. However, this sort of activity fundamentally has its limits when conducted from approaches that contain similar thought processes and are from similar perceived values. What is needed is the frequent putting together of different approaches.

The United States stands at the top of the world in the field of electronics, which is an advanced technology industry. However, the president of Intel, the world leader in logic elements, was born in Hungary, and the development of microcomputer chips in the United States has depended greatly on the brain power of immigrants, researchers, and students from overseas. These people come from many nations, including India, Israel, and Switzerland.

This fact is significant because if Japan wishes to become a technological power, it will need to plan for large-scale international exchanges of personnel and information. In our country where "harmony is prized" in the form of one people and one language, the discovery of an improved method was exalted in the past. However, today when we play catch up to Europe and the United States in any number of technological fields, if we are to discover the road to creative technological development, Japan must have exchanges with foreign researchers about different concepts rooted in different cultures.

(3) Japan's Responsibility

The discovery of the steam engine in Great Britain led to the Industrial Revolution. The results of chemical research in Germany led to the foundation of chemical engineering in the world. The results of electronic technology research in the United States produced the worldwide flourishing of today's electronics industry. These events were causative factors for the economic development of the world. Now Japan, which has become a present day economic power and technological power, as can be seen from the examples if Germany and the United States, must open itself internationally to creative research and development that will adorn the pages of scientific history. Through the progress of this research and development and the spread of its success, Japan will be obliged to contribute to the vitality of the world economy and to its growth. In other words, it is no exaggeration to say that Japan is in a position for the first time in its history to contribute actively to the development of the world.

From this sort of perspective, we need to keep in mind the increase of international research and development cooperation with Europe and the United States, and deal positively with international research and cooperation.

3. Japan's Contribution in the Field of Science and Technology

(1) Internal and External Conditions Surrounding Industrial Technology

The increase of trade friction surrounding our country in recent years, in addition to being a volume problem of a large current accounts balance of payments surplus, is increasingly a quality problem of technological friction

with Japan's superiority in the trade balance involving products with a concentration of technology, or advanced technology products fields. For example, cases have occurred recently where measures have been taken from the standpoint of national security to restrict the attendance at academic conferences or the exchange of investment in high technology field.

The reason for this is that with the importance of research and development increasing in every country, all are placing a high priority on technology policy. For example, in Europe, joint research and development is being conducted within the EC, beginning with the Eureka Project and the Esprit Race Projects, which have as their objective the common handling of industrial technological development. In the United States, the object is to move ahead with SDI, which has research and development in high technology as its object, and which is substantially under the rubric of national security. Moreover, the Science Park concept in the United States, the object of which is the strengthening of cooperation among industry, government, and the university, has expanded in recent years. One factor behind this is the tendency to attempt to nurture the results of research and development by industrialization in one's own country.

In contrast, Japan has an export surplus in the balance of technology trade with regard to electric machines and transportation machines, both of which fall within the large export balance of trade surplus Japan has in manufactured goods. Moreover, the trend in a large surplus continues in the balance of technology trade with North America and Europe whose countries are advanced in technology. This indicates the low level of Japan's contribution in the field the technology development. We believe this to be the underlying cause behind the criticism from foreign countries.

In this manner, technology friction increases in the high technology fields, especially among the technologically advanced countries, and a great concern about technology exists in every country. It is vital that Japan, which now occupies a position in the top 10 percent of the nations in the world, deal conscientiously, as a top 10 percent nation, with the increasingly important technology policy.

(2) The Passivity of Japan's Research and Development System

It is often said that research and development in applied fields is a strong point in Japan, but creative research and development is not yet a strong point. In particular, research is still in the exploratory stage. In the future, in spite of the fact that the area of research will grow greatly and is certain to shope one of the mainstreams of research and development, individual researchers still carry out their research in a decentralized fashion in all sorts of research areas. Building an environment to discover and bring forth new blossoms from amidst such a condition of confusion has traditionally been the greatest weakness for Japan.

When new areas of research arise, in many cases the direction of the research is confirmed as international conferences and symposiums are held that take the new research area as their theme, and as individual researchers who have

been doing the research in scattered areas of the world congregate. At these conferences, it becomes apparent what research is lacking. Then, as the research progresses, the forums of international exchange expand, and the research system is established within each country. In the midst of this process in virtually all cases, Japan has been the recipient of information. Activities of this kind where the buds of new technology are picked up and are fostered into great research areas are always conducted under the initiative of Europe and the United States. The general pattern for Japan is to improve upon that success and absorb it. The fact that Japan still maintains a large trade surplus as a technologically advanced country in high technology areas reflects the reality that Japan still is weak in creative research and development and has not shed the passive posture of a recipient of buds of technological innovation introduced from other countries.

The United States Congress has reacted to this sort of situation in Japan by stating that since the United States is superior in basic research, it would be impossible for Japan to produce goods for the market without the fruits of basic research in the United States. Moreover, among knowledgeable people in the United States, there is the awareness that Japanese researchers still expect the United States to play the role of discoverer of new technologies, and that Japanese businesses and the government still recognize the United States as the leader in basic research. The fact that our country has had 4 recipients of the Nobel Prize for the natural sciences while the United States has had 130 and Great Britain has had 62 clearly indicates the low contribution of our nation to the area of basic research. Bearing in mind the increase in importance of basic research since entering in 1980's, Japan has devised a variety of technology development policies, but in the future, it will be necessary to establish a long-term perspective and increase further our efforts.

(3) Lack of International Awareness in Japan's Research and Development Activities

Japan proceeds on its own in its research and development activities. We can be considered to lag in the information supply system because along with lacking in contacts with foreign countries, not being open with foreign countries about research and development successes, and not carrying out positive information exchanges, Japan's science and technology data base is insufficient. For example, with regard to the volume of research and development-related information to which Japan has access from overseas, our level is considerably below that of the level of the United States and the countries of Europe, which are technologically advanced countries. In our country, a positive spirit of international cooperation is lacking not only in research and development activities, but in general when it comes to social activities and the traits of national character. Behind this is certainly the resistance of the Japanese language, which is one of the most difficult languages in the world, and the geographical condition in which Japan is placed. However, the lack of a positive international spirit, when seen from the foreign side, is considered to exist because Japan consciously does not keep itself open and is a closed country. This factor gives rise to a misunderstanding. Moreover, in Japan, there is a tradition not to transmit verbally positive things about itself. To display this attitude is considered a fine trait. We cannot forget that this, at times, leads to misunderstanding by foreign countries.

Our lack of a positive international spirit is applicable to research and development activities. For example, the United States Congress has been arguing that the flow of technological information from Japan is sparse. Moreover, one can surmise this situation is behind the various protectionist policies, although only partially applied to Japan, of restrictions of technological information exchange, restrictions of investment exchange in the area of high technology, and restrictions of technology exports.

As far as Japan is concerned, we need to open ourselves positively and to open ourselves internationally in order to avoid needless criticism and misunderstanding from foreign countries and to move foreign relations along smoothly.

(4) Low Degree of Contribution to Fostering Researchers and Technical Experts

Most recently foreign countries have been pointing out that our contribution of creative researchers and technical experts is small when compared to foreign countries. The total number of foreign students accepted by our country is exceedingly small in comparison with the United States and Europe. On the other hand, the percentage of foreign students in U.S. universities is high. For example, the percentage of foreign students at the Massachusetts Institute of Technology, which is a mecca of high technology research and development, is 23 percent. The percentage of foreign university students at Stanford is close to 25 percent.

Within the United States, the argument that foreign countries are getting an "educational free ride" has been increasing in recent years. The argument states that U.S. money is being used to educate foreign researchers. In contrast, it is argued that the young researchers and technical experts from foreign countries raise the level of research in the United States, and have provided great support to the research advances of top U.S. researchers. While it is necessary to point this out to the United States, it is true that in the United States, a research and development environment exists which is highly appealing to superior researchers and technical experts. The fact that our country's top level researchers and technical experts virtually all have the experience of conducting research and development under an attractive research and development environment in foreign countries, beginning with the United States, is because U.S. research education organizations, in the end, have played an important role in the education of researchers and technical experts up to now.

As far as our country, which is now in the top 10 percent of the world, is concerned, it is important to make a positive contribution to the education of researchers and technical experts by working to build an attractive environment so that superior young researchers and technical experts will come here in the future.

4. Human Frontier Program

(1) Challenge of the Frontier

One of the keys to meeting the tasks of the 21st Century is, with biofunctional applied technology at the center, to determine how to develop and revolutionize

the trend of current technology. This is the origination of new concepts of technological development and the challenge of areas where men have not tread before. Because of our country's national power base, high technology level, and place in international society, the feeling is notably great that our country could take the greatest initiative in the world in this field. This field contains a breadth, which should be compared to a pioneering leap into the majesty of space and which could be considered for the depth of its research and development and its unlimited applications.

On the basis of Japan's initiative, which will tie the wisdom of mankind to the creation of a new industrial society, we will draft an international research and development program to create such a new area.

(2) Research and Development Themes

In the special table are presented research and development themes that will produce the breakthrough to the new era and are worthy of the challenge of the frontier. All of these research and development themes are tasks belonging to the fusion of the high technology of biofunctional applied technology. These are the themes expected to be the keys to creating the breakthrough in the industrial technology system that will exist in the 21st Century.

(3) How Research and Development Should Proceed

A. Basic Thinking

Although those research and development themes will blossom as the common assets of mankind in the 21st Century, the condition of research and development at this point in time is in the basic stage. In other words, we are at the stage where the sprouts of new concepts and ideas of researchers and technical experts can be supported on the basis of scientific and technical knowledge, and with foresight, we can evaluate their potential. In our nation, we are proceeding slowly and in an organized fashion with research and development at a basic stage on the basis of these new ideas and principles, and we are relatively lacking in the experience to nurture these sprouts of new technology. With regard to themes that are in the exploratory stage as these themes are, and where a breakthrough cannot occur without a free and friendly flow of knowledge from different fields, it is indispensable that authorities having a centripetal force gather in one place, clarify the concept of the theme by repeated brainstorming, and make known the best way to proceed with future research and development. It is also an urgent task to create an environment for this sort of abundantly creative research and development. The best ways to deal with this should be pointed out from various quarters. The common points to be noted can be summarized as follows.

(a) Capable leadership and the close exchange and mutual enlightenment of talented researchers and technical experts.

(b) Introduction of competitive conditions in the basic research stage.

(c) Promotion of the exchange of researchers and technical experts from different fields of research and the effective use of research and development resources.

(d) The rational use of the research support system, such as the preparation of the latest experimental research facilities, the improvement of the means for handling results, the preparation of documents and data, and improvements in the experiment and analysis system.

Other improvements in the life environment should also be brought up.

First of all, although it goes without saying that many talented researchers and technical experts are needed, project leaders are becoming extremely important who, along with leading the individual researchers and technical experts, put together the project. Moreover, with regard to basic research, the idea of "something emerging from the free ideas of researchers and technical experts" is, in Japan, likely to flow in the direction of non-intervention and non-competition. On the other hand, there was the tendency in Japan for researchers and technical experts to confine themselves to their own little corners. However, many of the ideas of even those people abundant in creativity arose through exchanges with a variety of researchers and technical experts, and new scientific knowledge and innovative technology has occurred historically in forums where the exchange of researchers and technical experts flourished. Moreover, to achieve such development of science and technology, strict assessments and critiques are necessary. Both cooperation and competition exist in the midst of a lively exchange over science and technology. Research areas in the future will increasingly cross the boundaries of academic disciplines and fields of business as well as national boundaries. The development of science and technology will develop on the international stage, crossing over former boundaries. Although competition will be strict, cooperation exceeding past frameworks will become extremely important. Exchanges of different fields and international exchange are extremely important. The rapid improvement of free and lively forums of research exchange are becoming necessary. In particular, our country, which 40 years after the war has developed science and technology without military technology, has progressed to a stage where other countries recognize our industrial technology. Moreover, the freedom of research activity is fully guaranteed and the attractiveness of our country's research and development environment is rapidly increasing among the world's researchers and technical experts. From this sort of perspective, we need to meet expectations by improving our research support system to widen the acceptance of talented foreign researchers and technical experts and to improve the living environment.

Consequently, research and development has begun to require much more personnel, money, and time. In particular, technological innovation has become noteworthy for the high cost of experimental research equipment and devices, a high cost that accompanies the increase of function and performance. It has become difficult for the various research institutes to own the latest high cost equipment and devices, and the percentage of the equipment and devices that is jointly owned is increasing. This common ownership has afforded researchers and technical experts the opportunity to get together and can be considered to play a role in the promotion of research cooperation.

Because this research and development project requires the participation of every sort of research field, there is a need ot carry out the drafting, changes, and assessment of the project while grasping the overall research and development.

Special Table - Sample Research and Development Themes

Sample Theme	Outline of Research and Development	Anticipated Results
Innovation of a production process imitating the chemical process in the body, and the development of new material	To make production of the new material possible by understanding the basis of the bodily functions and applying and imitating them. Also aiming to save on resources and energy in the production process. -Understanding and creation of enzymes having high catalytic functions and their reactive systems. -Development of an energy saving process of highly selective separation and refinement by transporting materials of the body membrane and by developing membrane resembling the artificial macro molecular body membrane. -Understanding of the nitrogen fixing system in the atmosphere and the development of nitrogen fixing technology under normal temperature and normal pressure that makes use of a catalytic function resembling it. -Understanding of photosynthetic function and development of technologies such as photoenergy, hydrogen production, and carbonic gas fixing reactions which make use of its catalytic function. -Understanding physiological makeup of human beings, and development of new materials, such as biologically appropriate materials, physiologically active materials (anti-cancer agents, specialized controls, immune relationships, and glycolipids)	-Increasing the safety of the production process of high heat and high pressure to one of normal heat and normal pressure by means of artificial enzymes. Along with this, obtaining product of high purity by carrying out high reactions of an especially different character [Natural resource energy, and environmental measure] -Anticipating a revolution in the waste reduction and environmental safety of petrochemical fuels by shaping ecosystems that make use of solar energy in the extreme. [Natural resource energy, and environmental measure] -Making possible the accumulation and natural resource creation of materials that were unusable and unrecoverable in the technological and economic sense in past processes. [Natural resource energy policy] -Making possible the manufacture of various new chemical products that were impossible by the former oil-centered chemical synthesis, and working for stabilization by the development of systems using raw materials that can be reproduced (first step to a non-oil civilization) [Natural resource energy, and food policy] -Being able to supplement or prevent the reduction of metabolic functions caused by aging. [Aging policy]
Development of new information processing and control systems to resemble the function and structure of the brain and nervous system, and of new electronic materials to realize these.	To realize artificial intelligence and an information processing system that function almost like the brain by understanding and improving on the brain and nervous system of human beings. -Realization of the learning, associative, and judgmental functions (self-organization of information) -Development of new sensors by understanding the functioning of the eyes, and such. -Development of software with the high-level function of making a dialog between machines and humans possible (understanding of pictures, sound, and language) -Construction of decentralized and tight control technology	-Overcoming the software risks (Making detailed instructions unnecessary in the writing of programs and in repair and maintenance) [Harmony between science and technology and human beings] -Making possible instructions by the ability to recognize pictures and sounds and by all kinds of writing and diagrams. [Aging policy] Realizing genuinely intelligent robots [Harmony between science and technology and human beings] Maintenance of a balance of daily life and intellectual life by compensating for the decline of the sensory and motor functions caused by aging. [Aging policy]
New power system modelled as the motor system of the body.	-Understanding and improving on the motor functions and adjustment functions of the muscles, flagella, and cilia that make up the body so that bioengines can be developed that are power devices which operate under normal heat and normal pressure and whose energy conversion efficiency is high. -Development of new robot technology that incorporates the motor functions of the body.	-Making wide use of all sorts of new systems as highly efficient and unpolluted sources of power. (Past internal combustion engines that used hydrocarbons as their raw material converted chemical energy to thermal energy and then to kinetic energy, but in contrast, bioengines convert chemical energy directly into kinetic energy.) (In the super long-term, there is the possibility of an alternative comparable to the internal combustion engine.) [Natural resources energy and aging policy]

When we consider the use of exchanges of different fields, international exchanges, and the gathering together of the latest high priced equipment and devices, a central organization is needed from the relatively early basic research period to carry out these functions. There is a need for a new central organization able to deal with foreign and domestic researchers and technical experts entirely without discrimination. Of course, even existing organizations need to expand as much as possible a system that accepts visiting academicians and researchers, and makes greater efforts towards the acceptance of domestic private sector researchers and technical experts and foreign researchers and technical experts.

B. Concrete Scheme

In order comprehensively to advance biofunctional applied technology research into the 21st Century on the basis of the fundamental thinking laid out in the previous sections, there is a need to establish the Human Frontier Program Advancement Center (tentative name) to carry out the following enterprises.

(1) To draft a comprehensive vision related to biofunctional applied technology research and to review subsequent requirements.

(2) To establish exchange forums, such as symposiums to carry out exchanges of researchers and research results.

(3) To establish a research and development fund, invigorate domestic and foreign research organizations and companies, and to promote the key research and development tasks. For that purpose, carry out the selection of tasks and the practical control of projects.

(4) To make use of domestic and foreign research organizations by establishing central research institutes and maintaining high level research facilities. In addition, in terms of the major research and development tasks, the areas that need close cooperation among different fields, and the existing research organizations that require the same, need to carry out research and development of areas that are falling behind. The research staffs of central research organizations should bring together their research and development and plan and support appropriately the aforementioned enterprises of the institution.

(5) To foster researchers by actually doing research and development.

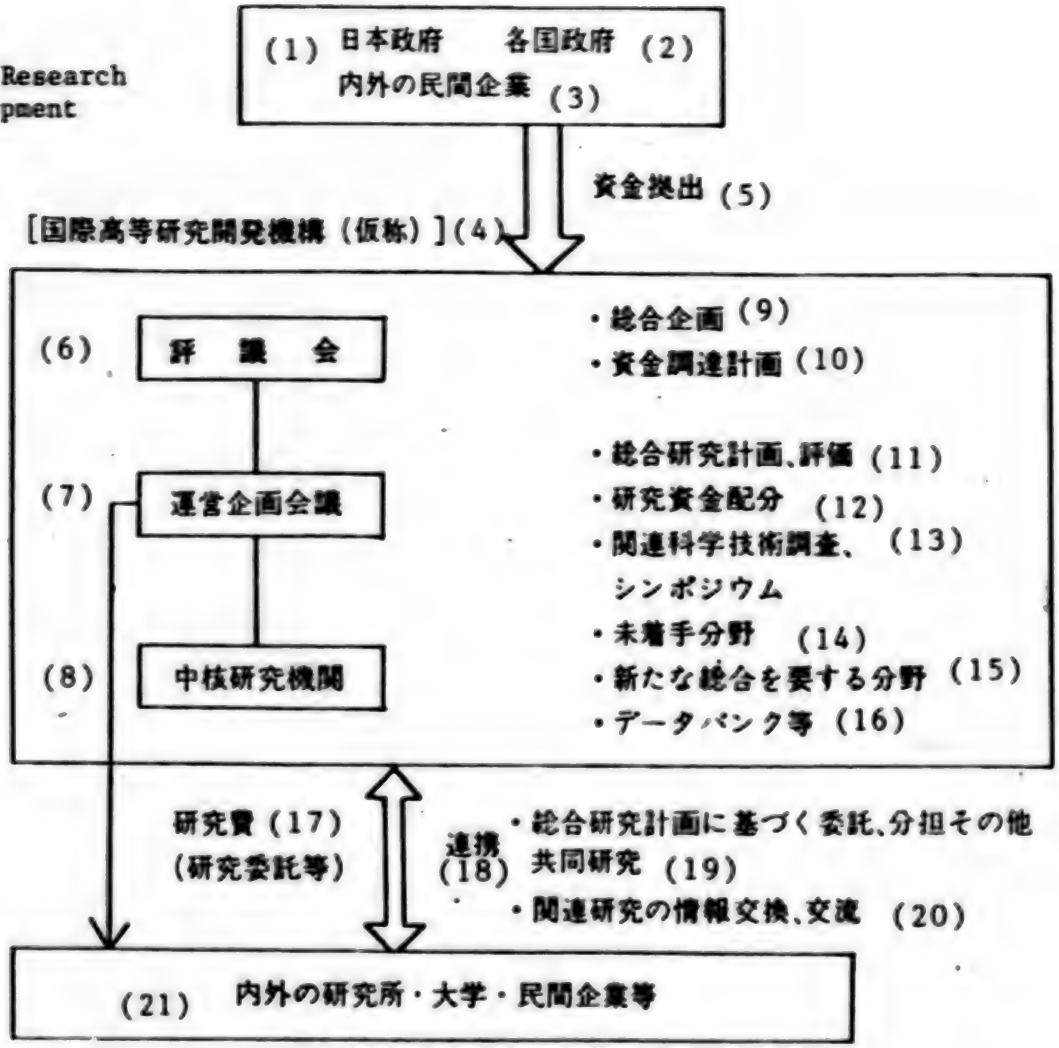
(6) Enterprises connected with the necessary facilities in the above enterprises (computers, data banks, research facilities, large and small international conference rooms, dormitory facilities) are needed.

It is important that the management of the Human Frontier Program Advancement Center (tentative name) be carried out along the following lines.

(1) To open the system internationally, make foreigners a considerable part of the institutional and central research institute staff, provide research and development funds overseas, and carry out international acitvities, such as holding symposiums.

Reference

Scheme of Research and Development



Key:

1. Government of Japan
2. Governments of various countries
3. Domestic and foreign private companies
4. International High-level Research and Development Institute (hypothetical name)
5. Funds contribution
6. Council
7. Management planning conference
8. Central research organization
9. Comprehensive plan
10. Funds procurement project
11. Comprehensive research program, evaluation
12. Research funds allocation
13. Related science and technology surveys and symposiums
14. Fields not yet started
15. Fields requiring new integration
16. Data banks
17. Research costs (research consignment, etc.)
18. Cooperation
19. Consignment and allocation of joint research on the basis of the comprehensive research program
20. Exchange and interchange of information of related research
21. Domestic and foreign research institutes, universities, and private firms

(2) To work together in association with existing domestic and foreign research organizations and firms, and to carry out consignment of research, joint research, and symposiums to promote exchange among these organizations.

(3) To put together systems so that researchers from a multitude of expert fields and foreign researchers can participate in many ways over the short-term and mid-term.

(4) To create a system that ensures the independence of the central research institute in order to carry out throughout the system a research and development theme well over the super long-term.

(5) To work together with, and to study making improvements with, existing research and development organizations for the fostering of human talent through research and development.

The establishment of the Human Frontier Program Advancement Center (tentative name), in fact, will be carried out in stages. What should be launched rapidly as the first stage is (1) the gathering of knowledgeable researchers from many fields, both domestic and foreign, to draft a research and development vision, (2) to carry out part of the important research and development tasks by making use of existing research organizations, and (3) drafting the plan of the next stage, such as the concrete concept of the central research organization. The funds required for this project should be paid over the long-term by both domestic and foreign public and private sectors because the project should be advanced under the cooperation of the domestic and foreign public and private sectors and its results will extend to all. Nevertheless, because an international contribution is being sought from Japan and because this project is super long-term, Japan, and the Japanese Government within that, in the earliest stage, needs to take the posture of contributing the lion's share of the funds.

12259/8918
CSO: 4306/3038

ACTIVITIES OF NTT, COMPETITORS IN MARKET REPORTED

Tokyo VOICE in Japanese Dec 85 pp 128-149

[Article by Hiroshi Ando, economic journalist, and Junji Tsuji, system planning consultant]

[Text] Epochal Policy Switchover

"Thou, a human mountain! Be careful not to trample underfoot my gentle subjects, horses, and wagons when walking the roads." This is a quotation from "Gulliver's Travels" as translated by Yoshio Nakano. This was the condition that the King of Lilliput had imposed on Gulliver--a castaway on the Land of Pygmies and there called the Mountain--when unchaining him and setting him free. Nippon Telegraph and Telephone Co., Ltd. (NTT), which marked its debut as a private company in the wake of the deregulation of the telecommunication business in April of this year, is literally a "Gulliver." As with the true Gulliver, NTT is also required to walk a tightrope lest "it should trample competitors down." Besides the legal constraint imposed on it, NTT also must fight off a voice calling for its divestiture that has been heard since the Commission for Extraordinary Administrative Reforms report emphasized the maintenace of "an appropriate setup where competition exists."

The picture surrounding NTT is further complicated by the domestic data processing and service industries and equipment vendors who are gallantly challenging the "Gulliver" and by the movements of overseas giants who have established a foothold in our country.

In pursuit of a share of the business, a large number of firms, old and new, small and large, domestic and foreign, are flooding into the newly emerging industry called telecommunications where the "Gulliver" NTT is soaring high above them all. A new wave of competition and cooperation is about to rise. It is also a movement that will trigger a new development of the entire industry of Japan.

While paying attention to what effects deregulation of the telecommunications and privatization of NTT will have and to the international relations centered on the U.S.-Japan economic friction, let us examine the movements and stratagems of the leading actors in the telecommunications field.

¥19 Trillion Market

The essence of the Telecommunications Business Bill that took effect on 1 April this year along with the "Nippon Telegraph and Telephone Company Bill" lies in the fact that the government has changed policy on telecommunications. That is, in administering the telecommunications business the government has opted for the policy of freedom as a rule over the spirit incorporated in the "Public Telecommunications Law" with a strong undertone for regulation. To be more concrete, any company can now enter the market for telecommunications service which was almost totally monopolized by NTT and Kokusai Denshin Denwa Co., Ltd., the former in the field of domestic service and the latter in international telephone business. To clarify the nature of competition in the telecommunications market which is quite different from conventional corporate rivalry, the writers will dare to dwell on the contents of the "telecommunications business" described in the new bill, although it may be confusing to the reader.

Firms engaged in telecommunications business are divided into A-category and B-category. Included in the A-category of business are companies who have communications circuits of their own and provide communications services. In short, these are enterprises which provide the same kind of service NTT has conventionally been supplying. Companies which lease circuits from the A-category of businesses and provide communications services are lumped into the B-category. As can be easily imagined, firms belonging to the A-category will have to make a large capital investment since they have to build up their own communication networks. Against them, firms belonging to the B-category require investments of a small to medium scale; with the ingenuity of the industrialists, they can meet the various user demands for service. They are thus more nimble and versatile.

The B-category business is further subdivided into two classifications. Providers of large-scale communications service using equipment installation with a capacity for more than 500 circuits and providers of communications service with foreign countries, all targeted for a large number of unspecified users, are all lumped into the B-category special to distinguish them from the ordinary B-category industrialists. Under the new bill, providers of A-category, special B-category and ordinary B-category, each with a differing degree of government control.

Not surprisingly, the more a category is considered to have an impact on the welfare of the public, the more demanding the condition becomes for an aspirant trying to enter the field, and the more rigorous the government supervision becomes over the way a business is run in it. (See Table 1) A business entering the ordinary B-category business, a business field catering to a small number of specified users, will require reporting to the authorities. The entry into the A-category business and special B-category business is a different story. Based on the thinking that "the capacity to make sufficient investment into equipment that is required of a business that caters to a large number of unspecified customers and the capability to operate the equipment on a secure basis are inevitable."

Businesses or enterpreneurs trying to advance into those categories of telecommunications business are required to submit to the Ministry of Posts and Telecommunications (MPT) a request for "license" or "registration," attaching a report listing outlines of the equipment and a document giving business plans, for required examinations.

For private companies, the A-category and special B-category are business fields that they have never experienced before. In the field of the ordinary B-category business, however, a service targeted for small and medium enterprises called "Small- and Medium-Scale Enterprise VAN" has been approved since the fall of 1982. This time, approval has been given to operating a VAN service targeted for big enterprises.

NTT, the forerunner and the largest of telecommunications service providers, is going to engage in both the A-category and B-category business. Opinions are divided about the propriety of NTT's being engaged in the two categories of service not only from the point of view of the nation's anti-monopoly law but also from the viewpoint of maintaining rationality in corporate management. The report of the Commission for Extraordinary Administrative Reform proposed separation of the corporation's data communication equipment and service division (meaning part of the data communication bureau). But partly because of the opposition from the entrenched NTT bureaucrats, the new bill does not go as far as that, but merely calls for revisions of whatever shortcomings may surface in the future.

How big will the newly emerging telecommunications market grow in a near-term future? According to estimates contained in a November 1984 report titled "On the Path To Increasing Sophistication of the Data Communications Industry" submitted by the "Committee on High-Level Growth of the Data Communications Industry" in the Telecommunications Council, MPT, the markets for both the A-category business and B-category business are expected to register a large gain, with the former expanding from ¥4 trillion in 1980 to ¥11.8 trillion in the year 2000 and the latter from ¥1.4 trillion to ¥7.2 trillion in the same span of time. The combined 1980 market of ¥5.4 trillion is expected to expand to ¥10.4 trillion in 1990 and to ¥19.1 trillion in 2000, thus achieving a 3.5-fold expansion.

Almost all of the telecommunications business in Japan was monopolized by NTT, and it accounted for 1 percent of the total domestic production. By the end of the century, the ratio is expected to grow to about 1.8 percent, which is to say that the weight of the telecommunications business in the nation's economy is expected to increase to about double what it is today.

Challenger's Stratagems

The following introduces profiles of a colorful band of challengers vying for a foothold in the newly liberated market. As of 21 October 1985, five companies have been given a license to engage in A-category business by the MPT minister (Table 2) and eight firms have registered with the MPT minister

Table 1. Business Classifications in Telecommunications Business Bill, and Points of Major Difference

Business division	A category	B-category	
		Special	Ordinary
Procedural requirements with MPT	License from MPT minister	Registration with MPT minister*	Report to MPT minister
Control on foreign capital	Ratio of foreign capital below one-third	No control	
Determining tariff rates	Approval of MPT minister	Report to MPT minister	Decided by provider
Duty of open disclosure of incorporation provisions	Yes	Yes	Yes
Under supervision of MPT minister for improvement or not	Yes	Yes	Yes

Note: Registration connotes a concept that is on the border between license and report.

TN: MPT is the Ministry of Posts and Telecommunications

Table 2. Outline of New Entrants Into A-Category Telecommunications Business

Daini Denden Co., Ltd.

Capitalization: ¥8 billion

Major partners: Kyocera Corp. (28 percent); Ushio Electric Inc. (2.5 percent; SECOM Co., Ltd. (2.5 percent); Sony Corp. (2.5 percent; Mitsubishi Corp. (2.5 percent)

Service area: Tokyo, Aichi Prefecture and Osaka, and their surrounding areas

Scheduled service startup: Exclusive line--December 1986; telephone--October 1987

Equipment: Microwave

Initial capacity: 5,760 circuits in terms of Tokyo-Nagoya-Osaka telephone-class calls

[continued]

[Continuation of Table 2]

Nippon Telecom Co., Ltd.

Capitalization: ¥9 billion

Major partners: Japanese National Railways (33.4 percent); Sumitomo Corp., Mitsui & Co., Ltd., Mitsubishi Corp., Nippon Express Co., Ltd., Tekken Construction Co., Ltd., Nippon Densetsu Kogyo Co., Ltd., The Railway Welfare Association, and Testsudo Kaikan Co., Ltd. (each 1.1 percent)

Service area: Areas along the Tokaido, Sanyo, Tohoku, and Joetsu Shinkansen lines

Scheduled startup: Exclusive line--October 1986; telephone--October 1987

Equipment: Optical fiber cable

Initial capacity: 4,320 circuits in terms of Tokyo-Nagoya-Osaka telephone-class calls

Nippon Kosoku Tsushin (high-speed communications) Co., Ltd.

Capitalization: ¥8.3 billion

Major partners: Toyota Motor Corp. (6 percent); Road Facilities Association (6 percent); Mitsubishi Corp. (3 percent); Mitsui & Co., Ltd. (2 percent); Sumitomo Corp., C. Itoh & Co., Ltd., Marubeni Corp., and Nissho Iwai Corp. (each 1.8 percent)

Service area: Areas along the Tomei and Meishin expressways

Scheduled startup: Exclusive line--November 1986 telephone--September 1987

Equipment: Optical fiber cable

Initial capacity: 5,760 circuits in terms of Tokyo-Nagoya-Osaka telephone-class calls

Nippon Tsushin Eisei (satellite communications) Co., Ltd.

Capitalization: ¥3,225 million

Major partners: C. Itoh & Co., Ltd. (40 percent); Mitsui & Co., Ltd. (30 percent); Hughes Communications (30 percent)

[continued]

[Continuation of Table 2]

Service area: Nationwide

Scheduled startup: February 1988

Equipment: Communication satellite; tracking and control stations

Initial capacity: Number of transponders: 32 x 2

Uchu Tsushin (space communications) Co., Ltd.

Capitalization: ¥100 million

Major partners: Mitsubishi Corp. (75 percent); Mitsubishi Electric Corp. (25 percent)

Service area: Nationwide

Scheduled startup: April 1988

Equipment: Communication satellite

Initial capacity: Number of transponders--35

Note: All five firms have obtained a license as of 21 June 1985

to inaugurate special B-category businesses (Table 3). An additional 165 firms have reported to the MPT minister their plans to start ordinary B-category businesses. Among the 165 firms belonging to the ordinary B-category business are included the 85 who reported to the MPT minister their plans to start the Small- and Medium-Scale Enterprise VAN services under the old Public Telecommunications Law and who have automatically been transferred into their current category (with the enactment of the new bill).

First, let us examine the A-category business. An equipment installation oriented business, the A-category business is said to require an initial investment of at least ¥50 billion, needing close to 10 years to recover the investment. Three ground system-based firms and two satellite-based firms have already entered the field, and they are poised for a slugfest seeking the No 2 position after NTT. Installing the necessary equipment and circuits, however, takes time, so even Nippon Telecom Co., which has a leg up on the competition, is scheduled to start business in October 1986. The field at present is far from competition.

Hantaro Toyoda, a managing director, says impatiently: "We are still at the stage where working-level groups from NTT and us, the new entrants into the field, are having preliminary talks over such issues as the dialing plans to interconnect local telephone circuits to our networks and the interconnection charges. It will be next spring at the earliest before we can submit

Table 3. Outline of Firms (New Entrants) in Special 3-Category Telecommunications Business

	Company	Major shareholders		Interconnections		Tieups (equity ratio, other partners)
		Equity investment	Scheduled investment	Connections	Projected connections	
Independent	Intech, Ltd.	Mitsubishi Electric Corp., GTE Net, etc.			GTE Telenet (TELENET)	Planet (25 percent, Lion Co., Ltd., Shiseido Co., Ltd.) Commex (30 percent, Mitsubishi Bank, Mitsubishi Electric Corp.)
	Kyodo VAN Co., Ltd.	Computer service C. Itoh & Co., Ltd.	Nippon Uninet	Nippon Uninet	Uninet Nomura Computer System (n-NET)	Software is provided by Nomura Computer System
Maker-affiliated	NEC Corp.			NEC Information Service (C&C VAN) Seino Information Service	GEISCO (MARK NET)	C&C International (50 percent, GEISCO), NEC Information Service (100 percent), Internet (18 percent, NTT, Nihon Keizai Newspaper, Fujitsu, Hitachi), Nippon EMS (technical corp.)
	Fujitsu, Ltd.			Fujitsu FIP (FIP-NET)		Fujitsu FIP (100 percent), Internet (18 percent, NTT, Nihon Keizai Newspaper, NEC Corp. Hitachi), Nippon EMS (scheduled)
	Hitachi Information Network Co., Ltd.	Hitachi, Ltd.		International Tymshare (Tymshare)	Network Service (TYMNET)	
	Oki Network Service Co., Ltd.					
User	Japan Information Service Co., Ltd.	Sumitomo Bank, et al.				
Foreign	Nippon EMS Co. Ltd.	Industrial Bank of Japan, Mitsui & Co., Ltd., KDD	AT&T (50 percent), Hitachi, Fujitsu, Toshiba Corp., NTT		AT&T (AIS-NET 1000)	

a request for approval of tariff rates. Although we have started marketing activity, the drive, we must admit, is rather short of steam." The company reportedly is banking on sales of the telephone service which it is planning to start in the second phase (1987 autumn) of its business activity program for 90 percent of earnings, and the first hurdle for it is whether it can smoothly execute projects according to the business activity schedule before the day arrives. Telecommunications business seems to be a long-term project. According to the aforementioned managing director, Nippon Telecom's basic strategy is "to set its tariff rates at a level 20 to 30 percent cheaper than rates charged by NTT and then to compete with other entrants in terms of customer service."

With the beginning of the year, some firms like Recruit Co. have started resale business of high-level digital exclusive lines. Confronted with the appearance at this early stage of "unexpected rivals," Nippon Telecom will probably be forced willy-nilly to revise its business activity program, by increasing capital outlays or by adding new attractions.

As for the other A-category of firms that use satellites, they are still at the stage of formulating a broad framework for business plans since they are not expected to start service by the spring of 1988. "Even a dream-come-true business has to pay commercially. We at present are working hard to determine the project's commercial feasibility," says Hiromune Minagawa, president of Space Communications Co.

As for the response of the leading corporations who are the prospective customers of the new telecommunications service providers, all of them invariably express their expectation of the new telecommunications service by saying, "We are [illegible]nting on the new entrants into the A-category business to apply brakes [illegible]spiral in communication costs." Their backing, however, has not gone be[illegible] the stage of spiritual support. The majority seem to be taking an attitude of "Let's see what NTT is going to do."

Next, let us see the special B-category business that offers VAN service. Entrants into the field include Intech and Japan Information Service, both small- and medium-scale enterprise VAN providers aiming for a great leap forward; NEC and Fujitsu, who plan to foster the small- and medium-scale enterprise VAN services that their subsidiaries have been supplying into much larger services; Nippon ENS, who is offering AIS-NET 1000, a multiuse VAN of AT&T, and Kyodo VAN, a joint venture of about 50 companies recruited on the basis of 1 company from 1 industry under the initiative of the leading software company Computer Service (CSK).

Drawing on the support of friendly corporate groups and long-term customers, they plan to chip away at the large-scale VAN market that has until now been the monopoly of NTT Data Communications Bureau. Over the September-October period of 1985, one after another, Intech, NEC, and Fujitsu have started offering service. The business is a demanding world where only those firms that have managed to mobilize their total resources can hope for success; the strategy, ingenuity, and business development they come up with is a matter of great interest.

Intech, for example, is considered a leader in the field in terms of investment into equipment and customer service record. What is characteristic of Intech's VAN business strategy is that the business has from an early date been incorporated in its corporate management program. That is, the embryonic business division that only demands investment but produces no dividends is being groomed as a "high-level communications business." It should develop into a next-generation money-making business after the current big winners "data processing," "software," and the "systems business" which is beginning to produce earnings. Intech has publicly shown its positive attitude toward the VAN business by forecasting in its seventh 3-year plan, that started this April, the division's sales of ¥10 billion in the plan's final year (1987). Asked about the prospect for achieving the sales target, company president Koji Kaneoka is a bit conservative saying, "That would be difficult. We consider an annual turnover of ¥6 billion as a break-even point, and achieving that is our current target." But the firm's equity participation in "Planet," a VAN service company started by eight household goods vendors including The Lion Co., and "Connes," a financial VAN service company inaugurated as a joint venture with the Mitsubishi Bank group (the two VAN companies are to use Intech's ACE TELENET) is considered a deepening confidence of its success in the VAN business.

Intech will have to keep on shelling out a lot of money for investment into the VAN-related facility and equipment. With the subsequent expansion in its network capacity, the access points (nodes connecting the circuits of its customer enterprises with its own packet network) is to increase from the current 60 to 100, giving the company a pause. The company's strategy of enriching the menu of its VAN service by establishing a cooperative relationship with other firms, such as international VAN connections in cooperation with GTE Telenet (United States) and IP Sharp (Canada), and subsequent interconnections of data bases and electronic mail, is also making steady progress.

Running second to Intech is Nippon Information Service affiliated with the Sumitomo Bank. In those days when the small- and medium-scale enterprise VAN was at its peak, the company had among its customers such firms as VISA Japan, Kao Soap Co., Ltd., and Kubota, Ltd., and these days it is commissioned with operations of VAN services connecting big and leading companies with their customer firms, such as VAN services for Plus, a stationary goods vendor, and Rengo Co. The firm is backed up by a rich experience of actually running VAN operations.

According to Takeshi Arakawa, chief of the planning and development division, the firm's VAN strategy is this: "The VAN service still has a long way to go before it can stand on its own feet as a self-paying enterprise. We intend to utilize it as a strategic tool in fostering our company into a leading all-round data processing service firm." The firm's effort for winning over leading enterprises among its customers, as mentioned above, is reportedly being advanced along the line of its policy as such.

Another group of leaders in the special B-category business is made up of major domestic computer makers (including firms associated with them).

In the days of the small- and medium-scale enterprise VAN these computer makers were not directly involved in the VAN business but had set up subsidiaries that undertook the job for them. These subsidiaries, however, were not necessarily fully equipped to run the van service in both the equipment and customer servicing, and thus failed to win any particularly high remarks in the industry. Beginning this April, the situation has changed. The makers themselves have begun to commit themselves fully to the VAN businesses, by reexamining the way in which the operations have until now been run and by establishing a full-fledged corporate structure by which to manage the VAN business.

Both NEC and Fujitsu are planning in steps to integrate their own VAN service networks with those of their subsidiaries. Hitachi, Ltd. is following a different path. It is going to inaugurate a new subsidiary that will manage its VAN operation. The new subsidiary is scheduled to take over the existing VAN service that its subsidiary has been running.

NEC, among others, has come forward with the most ambitious business plans. Beginning 1 October, it has started a new C&C-VAN service (with centers in Tokyo and Osaka, and with 70 access points) that uses packet exchange networks as its key network. The VAN service initially is scheduled to provide service in such areas as packet exchange, exclusive lines, databases (in a tie-up with firms in the field), PC communications, and private videotex. In NEC's business strategy, the VAN division is ranked fifth after electronic components, communications, computer, and home electronics, according to Shunzo Hamada, director of the VAN marketing promotion bureau. As if to back up the policy, the company, according to Hamada, is going to invest ¥60 billion into plant and equipment over the years until FY 1987, to increase the number of access points to 200 in the year, to be increased ultimately to 300. NEC's investment is several times over that of the industry's leader Intech.

As its main business activities, NEC has come forward with "international VAN" (it has already tied up with GEISCO of the United States. Upon realization of connections between MARK*NET of GEISCO and C&C-VAN, the C&C-VAN users will be able to receive service from the U.S. company's MARK-III and MARK-3000 service, and the reverse will also become possible), and further with "open VAN" (enabling mutual interconnections with VAN services offered by other companies).

As the basic revenue source, C&C-VAN can count on multimedia (voice, video, data) communications demands from NEC Group's management efficiency and office efficiency system. It will take "5 to 7 years," before the VAN service becomes profitable, according to Hamada.

Unique among the special B-category of firms is Kyodo VAN. The company was inaugurated under the initiative of Isao Okawa, president of CSK, with equity investments from corporate managers in various fields of industry who are deeply impressed with his corporate management ability. Although a new entrant starting the business from scratch, the company has managed to build up its corporate foundation in so short a period of time by

introducing the basic equipment for a VAN service between Tokyo and Osaka and by purchasing software for packet network control from Nomura Computer System. At present the tasks for the company are consideration of how to secure a pool of big customers that will create a source for basic corporate earnings, mastery of the network operation, and management technology. In mid-October, the company announced its tie-up with "RSA Network Group," an Osaka venture business grouping that is aiming at a franchise chain system of small-scale VAN service connecting regional retailers with wholesalers. This shows the firm's efforts for winning over customers at the grassroots levels.

The company is also of the same opinion that it will take a long time before its VAN business becomes profitable. "We are aiming at reaching a break-even point in 5 years after the start of business," says Tokusaburo Nagai, a director.

Another anticipated entrant into the VAN business is SECOM Co., Ltd., which has parlayed its start as a security company into literally an information company equipped with a sophisticated nationwide-scale network. In August 1985, it spun its network operation division to start an independent company called "SECOM Net." The strength of SECOM lies in its "foot" in the form of a nationwide scale system for cash transportation and in its comprehensive know-how of safety control. In October 1985, it inaugurated, in a joint venture with NTT, a new company called "Nippon Computer Security," a company devoted to provision of comprehensive computer security service. The undertaking is considered to reveal the company's intention to start an information and communications business of a great scale in both depth and scope.

The last is the ordinary B-category business that is designed to meet the demands for small- to medium-scale VAN services (services for intercorporation data communications best suited for meeting the demands of specific businesses or corporate groupings). The field is characterized by entrants from a broad spectrum of industry, including small and big businesses. Among the leaders are such information processors as Nomura Computer System and Toyo Information System. An interesting fact about the field is that IBM Japan is in it, but not in the special B-category business. Such distribution-related firms as Seibu Information Center, Pharma, as well as physical distribution and transportation-related firms like Yamato System Development and Seno Information Service are actively engaged in the business.

As a whole, the field is characterized by the type of service that conducts specialized business for a single business grouping, such as "development of an integrated on-line system linking several companies and its operation and management." But only a few of the firms in the field are expected to eventually move onto the special B-category business. The business is a sort of "venture business" where ingenuity plus a small amount of investment befitting a company's scale, can be expected to have great competitive power and effect. The market may see a rash of a wide variety of businesses that are highly successful.

A typical case of success in the field is the VAN service being offered by Pharma, a chain of voluntary stores dealing in drugs. Although a firm of small capital, it has been operating as a middleman between retailers affiliated with it, wholesalers, and makers. It relays or processes orders issued or orders received, and collects data on the best-selling merchandise. In this way it has suceeded in reducing the commissions on settlements of bills and in realizing efficiency in the flow of goods and business dealings. The firm is also offering the service for other associated firms in the area.

Toyo Information System feels that operating its VAN business on a self-paying basis will be difficult in the immediate future. So, it is taking a slow but steady approach toward the business, concentrating its efforts on enriching the contents of the value-added service as a demand for this service arises. Iness, a firm with 80 access points, is also aiming at gradual business expansion. Company president Kenji Karino says, "We are going to keep on making necessary investments, such as for building in redundancy of key elements of the network and for increasing the number of access points, but how much we will invest is determined by the progress in customer development."

The foregoing is a glimpse of the movements of the new entrants into the field. The impression one gets is that for most of them the business is still at the stage where "the effort is concentrated on foundation building (equipment and niche building) and "maneuvering by the top leaders or staffers in search of anything that may lead to a business deal." As can be seen in Iness president Karino's pronouncement that "in the competition for a VAN service in the physical distribution industry, having leading distributors as users of one's own company's information processing service is a potent weapon." The true nature of the VAN business as not a mere information processing business but as an enterprise that is closely involved with the customer's business, is coming to be understood and recognized widely. The very fact that as to the future of VAN business, there are two opinions, one bullish and the other conservative, seems to indicate the business's two aspects, that is, the great potential and the great difficulty.

Wily Gulliver

Let us call the period from before and after the birth of the new NTT under the new bill until the summer the first round, and the second round the period from the fall on down. The first round was characterized by the rash of new entrants into the telecommunications field. The second round is characterized by a stubborn rollback offensive by NTT. The ultimate of it all was a plan for a joint venture between NTT and IBM, made public on 25 September 1985. The NTT movement seems to have been accepted by many concerned people. The MPT, which has been working for liberalization of the telecommunications business, felt that "the development was much faster than expected." Judging from the superb timing of the announcement--just at the time when the three leading registered firms in the special B-category business were about to start services--and the scope of services the joint venture is going to offer, the decision marks a "decisive moment" for the two companies who are counting on the joint venture as a pillar of big business in the near future.

NTT's unfathomable mobility is reflected in its revelation on the day following its announcement of the joint venture with IBM that it concluded a comprehensive agreement with another U.S. behemoth, AT&T, on commodity development, management, and control. With these measures, NTT has shook hands with the U.S. giants who are waging a fierce battle in the U.S. market encroaching on each other's turfs, thus laying the groundwork for a system that will enable it to promote business activity and technical development on a global basis.

The establishment of NTT PC Communications in September 1985, a joint venture for planning, development and marketing of personal computer communications networks, has for NTT as much or more a meaning as other big-ticket business deals it has so far concluded, such as with IBM. The partner is a venture business called Logic Ssytems International. It is thought that a combination of NTT's nationwide network service and the growth potential of personal computer communications may result in concrete achievements in a relatively short period of time. As naturally expected, the series of NTT's bold movements have caused repercussions among various fields. Voices are heard in the Ministry of International Trade and Industry (MITI) that "the company is going a bit too far." Seen strictly from the viewpoint of business rationality, the cooperation between NTT and IBM, for example, has much merit. IBM has already established a controlling position in the computer markets in most of the countries in the world including the United States and EC countries, with the sole exception being Japan. For IBM, its cooperation with NTT is right at the mark if the computer maker is going to check its declining market share in Japan and turn its fortune upward. when looking into a crystal ball to see the shape of the future network society, it becomes clear that the absolute requirements for NTT are that it will have to be able to provide not only network services based on its own network standard DCNA [Data Communications Network Architecture], but also network services based on other makers' standards. For NTT, the first company it should be going after in this case is, needless to say, IBM that has many leading enterprises among the users of its machines. A "drastic cooperation with IBM" seems to be a strategy that would naturally come to anyone's mind. The effect of NTT and IBM teaming up is equivalent to AT&T and IBM shaking hands in the United States, and the potential market controlling power is unfathomable.

We cannot overlook the fact that the tense Japan-U.S. relations in the name of U.S.-Japan economic friction worked as a "catalyst" for the joint venture plan. The U.S.-Japan dispute over liberalization of the telecommunications market lasting since April has reportedly calmed down with the U.S. side coming to understand the Japanese situation. The issue may surface itself again if any real progress is not seen in "actual achievements in telecommunications business in the liberalized Japanese market." Under such a delicate situation, placing restraints on the activity of IBM, a U.S. corporation, in such fields as investment and building corporate partnerships, may backfire if protectionism is increased in the United States. There was seen in some quarters of the Japanese computer makers a movement aimed at blocking the NTT-IBM plan for joint venture, but the uproar has subsequently

tapered off. This and the wait-and-see attitude being taken by MPT, the government agency in charge of telecommunications, are all because of the political background underlying them.

The great repercussions that NTT's offensive has caused are again asking all the people concerned to reconsider how great an impact the former public corporation's privatization has had on the country. Besides upholding the duty that it has until now been performing as a public utility, NTT is burdened with another task beginning in April of keeping itself profitable. "Never repeat the mistake of the Japanese National Railways," this is the absolute task imposed on the NTT management. Granting it, hasn't NTT gone a bit too far in pursuit of profitability? Isn't it standing in the way for "revitalization of the market through competition," which is the aim of the new bill? This may be a good case of irony that the intention of the Anti-monopoly Act--bringing into full play the potential of corporations under the principle of competition--sometimes invites the ills of monopoly and oligopoly.

What is driving NTT to act so aggressively? One reason is that "although it has been privatized," it still is shackled by various restraints under the law because it used to be, along with the Japanese National Railways and the Japan Monopoly Corporation, a mammoth public body. The other is the lingering opinion calling for the company's divestiture that has been around since the report by the Ad Hoc Commission on Administrative Reforms was submitted. Under such a condition, NTT has probably resorted to an offensive defense tactic in the form of "reorganization of subsidiary company groups" in order to ensure "a long-term survival of a mammoth organization employing 330,000 workers." That is, although it is still placed under various constraints, the privatization has won it the right to freely make investment or equity investment, thus giving it the freedom to set up subsidiaries and joint ventures. This is reflected as a rash of subsidiaries that have been started at a pace of "two companies per month." The plans reportedly are to build up a new NTT family of companies numbering as many as 600, about equal to the total of Hitachi subsidiaries. The diversification also seems to be part of NTT's management strategy, in which career employees are loaned out to the subsidiaries to refine their management acumen. Those who distinguish themselves there are invited back to the NTT main office for promotion to management posts.

Movement Toward Information Networking

Let us here study the background that propelled NTT to such a frenzy of activity in search of investment opportunities and of business tie-ups with overseas firms which is rarely seen in the history of industry. In a broad sense, there is a trend toward liberalization of communications in the United States and European countries. On the domestic scene, we have to point out the movement for administrative reforms that was instrumental in the privatization of NTT. In this paper, we, however, describe only the most direct factor of them all, that is, the economic factor that would create demands for the new and old telecommunications businesses.

As in the case of the general staff of the military in wartime, information and communications has been an essential tool from an ancient time in grasping the state of the war from an elevated stand. Thanks to innovations in electronics technology in recent years. it has become possible to create, at reasonable costs, advanced data communications systems incorporating computer and communications. The corporate utilization of the advanced data communications systems has led individual companies to an elevated position from which to map out corporate strategy. They are indeed proving to be a source for corporate competitive power and for creation of new businesses. This is the background for the reason why such VAN-related phrases like comprehensive on-line system and network among corporations are often heard recently. What is meant by the "advanced information society" is a society governed by the self-control principle, in which the new vitality and order of society are kept by making the most of the basic power of the data communications system, that is, the capability to take an overall view of the situation and the power to shorten time and space.

For a company to be able to "command a bird's eye view," it would, by all means, have to have in place a set-up that not only enables it to know what is happening inside its own office but also affords it to obtain timely information about its customer firms and the needs of customers. This necessity has expanded the needs for networking from the network within a single company to one connecting several companies. This in turn has created the demand for VAN services that interconnect different models of computers in various companies.

Furthermore, as the demand for networking increased, there emerged a desire to pare down the costs of communications that have until now been considered as unavoidable fixed expenses. Backed up by such a current, the market for telecommunications business has developed into a market with a potential for unlimited growth.

Let us examine the concrete movements for inter-corporation networking (networking involving several companies) which is considered the field to have the largest latent demand.

The first is the financial industry that is at the heart of the flow of money. The banking industry, to begin with, is far ahead of other industries in terms of networks in place for joint use. Such systems as the Federation of Bankers' Associations of Japan money order exchange system and city bank CD joint utilization system (BANCS) have so far been realized. They are taking root as a social infrastructure. Furthermore, various measures have recently been taken to meet the needs for various types of networks linking corporations with each other. Some such measures are the planned start of a joint center for providing multibank report services for corporate customers and the adoption of the protocol for a bank POS system for city banks, which enables communications among different types of computers in preparation for the arrival of bank POS days.

It is not an exaggeration to say that the whole industry has needs for interconnections via networks with the bank, the center for account

settlements. The opinion of the majority of the city banks is, "Commissioning the operation of a network for joint use to any other than NTT can hardly be imagined in terms of neutrality and reliability. We only wish that if the force of competition would work in the market, communications costs could be brought down, such as the correction of the large differences in the costs between local and long-distance calls."

But as can be seen in the cases of "Comnes," a joint venture of the Mitsubishi Bank, Ltd. and others for development, management, and operation of financial VAN services and of the movement among the small- and medium-scale banks for the establishment of a joint center, the banking industry will increasingly be demanding the telecommunications market diversify services.

In the life insurance industry, efforts are being made for the practical use of a joint center incorporating the entire industry, while individual firms are making efforts for the sophistication of their systems.

The movement is part of the industry's effort for the development of an infrastructure for an industrywide system, in preparation for the arrival of the time when it will be confronted with cooperation and/or competition with other industries. The joint center initially will be engaged in the transfers of annuity and group insurance policies among the member companies. Once this data exchange service is automated, the merits will be great for both the insurance industry and customers. In the final stage, provision of a data registration and retrieval service--registration of the data concerning contents of an insurance policy contract is mandated under a system--is scheduled. In the field of development of new policies, the possibility is said to be not too far-fetched that "the industry agrees to underwrite the medical insurance system through the joint center."

The life insurance industry has commissioned NTT with the development and operation of the joint center, and the telecommunications company reportedly is going to provide the service by using its public financial network (a life insurance version of FINE). As to the industry expectation of what merits the deregulation of the telecommunications market would bring about, it is said that their greatest hope is that there would begin to work, seen from a long-term perspective, the principle of competition in the market and the starkness in the costs of communications would be avoided.

Plans are underway in the casualty and damage insurance industry for the start of an industrywide joint network. As things stand now, the industry has yet to commit itself to the idea of an industrywide network, and the plan is still at the stage where a study team of full-time members has been inaugurated to study concrete measures toward realization of the plan. Since the industry is relying on agents for more than 80 percent of revenues from sales of insurance policies, and furthermore most of the agents are working for more than two casualty and damage insurance companies, the necessity of a joint network linking the insurance companies with their agencies is all the more great. All the insurance companies agree on the need for such a system, and they are mulling over if such a link is really feasible.

In a desperate effort for winning an industry consensus for realization of a joint network, the casualty and damage industry reportedly has gone out of its way even to conclude an agreement among member firms, which binds them to exercise self-control in even establishing links with their agencies via such public networks as CAPTAIN and ANSER. In constructing an efficient and flexible information infrastructure of society, whether or not many industires have in place joint networks capable of solving basic problems common to individual industries is an extremely important element. The effort being made by the casualty and damage insurance industry is in the direction toward achieving that goal.

Outside of the financial industry, there also are seen some remarkable movements for construction of networks linking firms with each other, that is, VAN services. The most conspicuous of them all is the VAN company "Planet" which was inaugurated in August 1985 by eight vendors of daily necessaries aiming at rationalizing the flow of goods. The network service linking makers with wholesalers is joined by makers of products that are competitive on the market. In addition to the current 8 member companies, an additional 22 firms are reportedly planning to make an equity investment in the VAN company. According to plans, the number of wholesalers equipped with terminals is scheduled to increase from 146 firms this fall to 500 firms in 2 years.

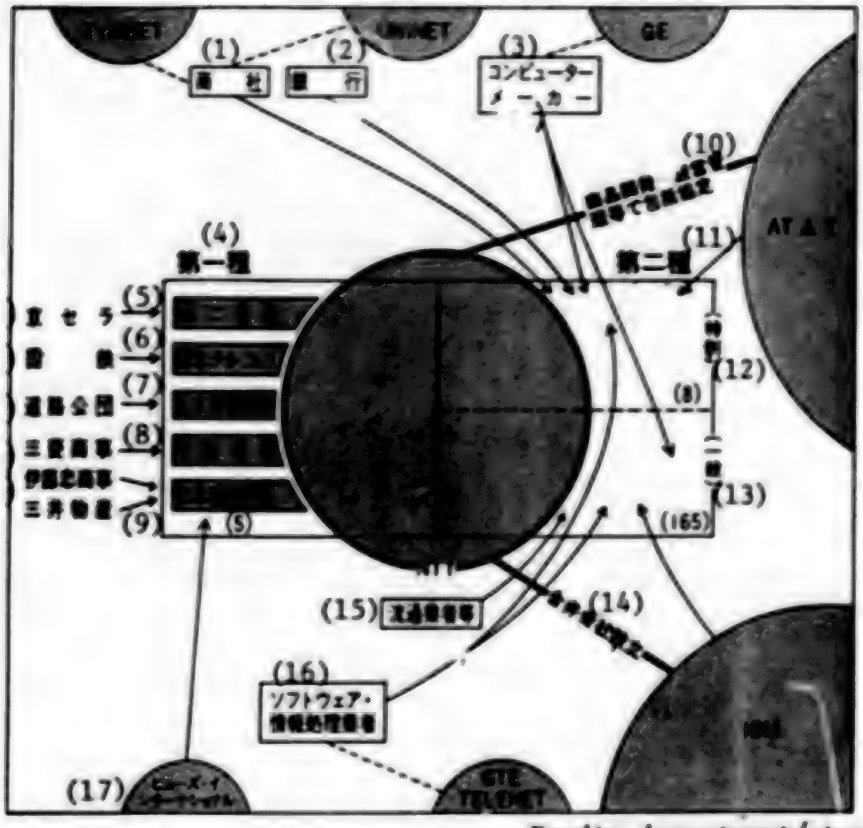
Another conspicuous move in addition to the establishment of Planet is the decision to "standardize the distribution information networks in the industry," a plan floated by the association of wholesalers of soap and detergents called the "National Federation of Associations of Wholesalers of Soaps, Detergent, Toothpaste, and Sundry Goods" and made possible with the cooperation of 88 firms engaged in their production. The wholesalers' association is an organization with about 2,000 members across the nation, and in March of this year it called on the makers to standardize the networks for issuing or receiving orders between the makers and wholesalers. On receiving the proposal, the "Japan Soap and Detergent Association," an industry association of soap and detergent makers, gave a reply wholeheartedly endorsing the proposal, albeit with partial revisions. The move also deserves a high mark as an industry-initiated movement for networks standardization in preparation for a high-level information society.

Fields of Domination

Lastly, let us examine the standing of NTT and those of the competitors while explaining the specific features of the telecommunications market in Japan.

The state of an overwhelming monopoly of the market by NTT and its subsidiaries will not change much even 10 years from now. The so-called Gulliver-type monopoly, in which under a tall figure of a giant small- to medium-scale competitors wage a fierce competition for a position, is expected to stay for some time to come. Some government officials even say that the repeated call by NTT president Hisashi Shindo, "We are looking forward to a healthy growth of the competition," is no different from the "growth of healthy

Figures in ( ) are number of firms established or applications as of 21 October 1985



—— Equity investment/start of business
----- Business cooperation

Figure 1. Domestic and Foreign Firms Entering the Telecommunications Business

Key:

1. Trading firms
2. Banks
3. Computer makers
4. A-category
5. Kyocera--Daini Denden
6. Japanese National Railway--Nippon Telecom
7. Japan Highway Public Corp.--Nippon Kosoku Tsushin
8. Mitsubishi Corp.--Ushu Tsushin
9. C. Itoh & Co. and Mitsui & Co.--Nippon Tsushin Eisei
10. Comprehensive agreement on merchandise development and management control
11. B-category
12. Special
13. Ordinary
14. Establishing of joint venture
15. Distributors
16. Software/data processing businesses
17. Hughes International

opposition parties," a pronouncement made by the authoritarian late Prime Minister Yoshida. What it means is this: In the same way that the Liberal Democratic Party has been able to conceal its long-term de-facto dictatorship helped by the presence of weak opposition parties, NTT will be able to barely counter the charge of "monopoly" helped by the rash of new entrants into the market.

Although privatized, NTT is still responsible for fulfilling the INS [Information Network Service] project, a sort of national project aiming at upgrading the nation's telecommunications networks by the end of this century. The corporation's character as a semigovernmental company is here to stay. With it, the passive interdependence of government business and private business that used to surround the former public corporation would not easily go away. With the economic friction between the two countries as its background, the United States has demanded that Japan take some measures to lessen NTT's monopoly of the telecommunications market, and the country has even threatened Japan with legislation of retaliatory bills. The upshot is that the United States, the harshest critic of Japan, is somewhat pinning its hope on cornering a larger share of the procurement by NTT as a semigovernment agency.

On the other hand, the force calling for increased liberalization and competition in the telecommunications market is expected to gain further strength. One of the reasons is that the increasing trend toward information orientation taking place in every field of industry is calling for telecommunications services which are much cheaper, efficient yet multifunctional. Another reason is that the voice calling for denationalization and liberalization of telecommunications business is not a phenomenon limited to Japan but that the current is flowing irresistibly in the advanced countries like the United States and Great Britain. In this way, NTT is expected to face competition with two conflicting attributes: moderation and conciliatory attitude toward the peripheral firms due to its character as a semigovernmental agency; and a combativeness that will enable it to win the world competition in telecommunications business.

Given the circumstances, the divestiture of NTT, an issue which was shelved when the old NTT was denationalized in the spring of 1985, may be said to be gaining an urgency. The direct impetus for the move is the call, represented by Intech president Kanaoka, for "competition on an equal footing," from new entrants into the market. Spurred by the announcement of a joint venture plan between NTT and IBM, the Fair Trade Commission has started a basic study to find out NTT's monopoly of the market.

More than anything else, from the viewpoint of increasing and expanding the company's competitiveness, NTT management itself seems to be increasingly inclined toward a divestiture. As duly expected, NTT and the government at the moment are showing a cautious attitude toward the issue in view of the negative opinion on the issue of divestiture that is mainly raised by the company's labor unions. NTT officials have come to keenly feel the disadvantages that accompany the company's involvement in the twin fields of A-category and B-category business. That is, the company's entire business

activity is confined within the rigid framework of the government licensing system which the A-category businesses are demanded to adhere to. One of the reasons used to explain why divestiture of NTT must be avoided was the reasoning that spinning the burgeoning data communications business (B-category) off from the conventional telephone business (A-category) would work as a hindrance for the company's invigoration. Today, the notion, however, seems to be gaining strength that NTT's vitality as a whole would be enhanced if the company divestiture and reorganization of the subsidiary firms progressed and if each of the subsidiaries was held accountable for its line of business.

Moves of Big U.S. Corporations

When forecasting the long-term shape of the telecommunications market in Japan, we cannot overlook the moves of the two giant U.S. companies, IBM and AT&T, along with those of NTT. As we have seen already, the two companies are maintaining a close relationship with NTT, but at the same time they are making steady inroads into the Japanese market by concluding business partnerships with Japanese firms from various sectors of industry. The consensus of opinion among concerned people is that the future direction of the telecommunications market will be determined by the relationships of competition and cooperation among the three world leaders, AT&T and NTT which occupy first and second position in the world ranking of telecommunications firms on the one hand and IBM, the world leader in computers on the other.

In the competition between AT&T and IBM in the Japanese market, the latter, with 50 years experience in the market, seems to be far ahead of the former at the moment. In the U.S. market, IBM's concentrated efforts reportedly are chipping away at AT&T's turf, telecommunications field. The only thing that is clear is that the two firms are promoting their strategies based on an extremely long-term and global basis. With the competition in the telecommunications field intensifying, NTT officials have reportedly been shocked anew at the superiority of AT&T in communications technology. For these reasons alone, NTT is said to have no option but to intensify its cooperative relationships with AT&T and IBM.

Companies entering the A-category and B-category of business are being willy-nilly forced to seek niches in the shadows of the three Japanese and American giants. The strong points for them are in most cases the business foundations they have built over years and assets. The Japanese National Railways and the trunk highway-related firms are the cases in the A-category of business and firms affiliated with the computer makers and/or banks and trading houses are the cases in the B-category of business. Of the leading trading firms, such behemoths as Mitsubishi Corp. and Mitsui & Co., Ltd. have equity interests in three or four firms out of the five entrants into the A-category of business. As the business of these firms catches on in the future, there may be a realignment of firms according to Zaibatsu groupings.

The newly emerging forces, which are independent of existing groups centered around banks, are expected to hold their own in their own ways. It is because money and people are flowing into Kyocera, Intech, SECOM, etc., from various fields, attracted by the unique talents of their managers. A conspicuous feature with the firms that have advanced into the special B-category of business is that among their managers are seen many who are planning to promote new types of corporate cooperative relationships involving various types of industries and use them as the basis for starting a VAN service.

Needless to say, the VAN market where more than 100 firms are competing will face a shake out. Also, in view of the intrinsic function of the communications network, the networks will increasingly begin to establish interconnections with each other, thus giving rise to a movement for a much advanced VAN service called "VAN of VAN's."

Despite the rash of news heralding new entrants into the telecommunications market and the competition there, it will be a long time before these new media come to be felt as something essential for our everyday living. For example, take the telephone. What is of most concern to us is whether its cost will go down? If so, by how much? Or will it increase its utility? All these questions are still wrapped in a shroud of darkness. In this respect, Japan is far behind the United States where TV commercials by VAN businesses touting "merits of our firm's services" are an everyday occurrence. Such phrases as "invigoration of NTT through competition" and "challenge to NTT" are talked about much these days, but the competition there, it seems, is nothing but competition on an artificially created market by law.

As in the past, the tariff rates for the A-category of businesses are still decided awaiting government permission or approval, so for the denationalized NTT, it is difficult to go it alone far away of the times. Allowing for that, the true objective of the denationalization of NTT and the deregulation of the market still must be to provide the general customers and consumers with efficient services at less costs. Even in this burgeoning industry which differs from existing industries in many respects, the condition for a firm that wins out in the competition for survival must be, as in other industries, how well it can meet with the needs of customers. We are expecting the telecommunications industry will produce a star performer, which, on the strength of its success in meeting with the needs of the general public, springs up to the top position.

20114/9365
CSO: 4306/1511

TELECOMMUNICATIONS

ROLE OF COMPETITION IN INS TECHNOLOGY AT NTT REPORTED

Tokyo JIHYO in Japanese Nov 85 pp 108-117

[Excerpts] Characteristics of NTT's Technology

What the NTT (Nippon Telegraph and Telephone Corp) engineering staff is now tackling with great interest is INS (information network system). The important fact about the technical development in this high technology field is that as untiring hard work and competition strengthen businesses, competition would result in rapid progress in technological fields also. Since competition in technical development makes it possible for competitors to mutually absorb their respective advantages, it provides many opportunities for technology to make rapid progress. It can be considered that as a result of the principle of competition being introduced, there has come the time when the capability of the NTT engineering staff can be freely displayed.

With regard to INS, NTT President Shinto says: "Looking toward the 21st century, NTT has now begun to adopt INS in earnest. It is not merely because we have the technical capability and the financial capability to realize it, but because now is the time when the telecommunications situation of the advanced nations of the world is urged to make qualitative changes in communications with the rapid development of electronics technology as a lever. Japanese society too is pressed for a change to an information society as an advanced industrial nation of the world. Should we cause any delay in INS, we would inflict a serious loss on Japanese society.

From the point of view of an international competitive power, the national welfare policy and the assets that should be carried over to the people of the next generation, the work to construct INS is a duty imposed on us. It is not merely from a narrow-minded view of convenience....

Also, with regard to the importance of technical development, NTT Vice-President Yasusada Kitahara says: "Telecommunications in Japan now hold the first place in the world both in quality and quantity, but we owe it very much to the constant efforts of our predecessors and also to our strikingly advanced technical development. They always boldly challenged new technologies and successively realized miniaturization and weight reduction, energy saving, cost reduction, etc. of telecommunications equipment, thereby becoming the driving force to build up the telecommunications society of today."

Since NTT began privatization, research and development in the telecommunications fields is what should be taken up as the most important theme at the national level. Hereafter, it is important to strengthen and replenish NTT's research and development; it can be said to be an unchangeable mission for NTT to maintain and improve its technical level as world leader. There may be various development themes remaining to be taken up. It is thought that such matters as semiconductor technology to lower cost and raise reliability, speed and function, optical fiber to transmit a larger capacity of information and large-capacity satellite communications technology, development of INS computers that control information processing, in the INS network, and development of input-output devices with good man-machine interface will become the important subjects.

Then, coming into the age of high technology and software, with what technology and engineering staff does NTT plan to grapple with the realization of INS society?

To Push Development of New Devices

Semiconductor technology represented by LSI can be said to be one of the greatest inventions in the 20th century and at the same time to be the core of technology in the 21st century. It is what is indispensable to the formation of a wide industrial foundation and is what supports INS.

The present goal of LSI development appears to be set at two points of 1) price reduction by mass production of LSI and 2) cost reduction per bit by high integration of LSI. Since memory devices are of a structure with relatively simple circuits and are used in a wide range and in a large quantity, their profitability for makers is high. Such being the case, world nations are now devoting all their energies to the technical development race for attaining a high integratica of memory devices.

Japan caught up with the United States in 1977 in the development of the 64-kilobit memory device, and the United States's SIA strongly denounced the inequity of IC customs duties between Japan and the United States. It was said that there were problems in criticizing the customs duties, and the United States changed the target of its criticism, saying that in the 64-kilobit DRAM, products of Japan, account for 70 percent of those of the world.

At present, it is said that the memory chip having the highest degree of integration in the world is the 1-megabit DRAM made public in 1984. What is planned to be developed next is a 4-megabit memory, and this is considered to be one goal of conventional technology based on ultraviolet exposure technology (very fine processing technology of 0.7 micron in stroke width).

NTT has already realized the stroke width of 0.5 micron by the development of a high-speed electron beam picture drawing equipment. At the same time, it has succeeded in 0.2-micron pattern transfer by using SOR facilities of the (High Energy Physics Laboratory) and has had the prospects also for the development of SOR small equipment.

Further, in the fall of 1984 NTT succeeded in the trial manufacture of a high-speed memory of 0.85 nanosecond (nanosecond is one thousand-millionth of a second) in access time (read velocity), the fastest in the world of all silicon base materials, and at the same time it led the world in succeeding also in the trial manufacture of a 16-kilobit memory using gallium-arsenide.

As the direction of future development of LSI, it appears that measures will be taken to push the development of new devices and at the same time to concentrate energies, on the other hand, on the development of new devices having superior functions that have not been in the existing LSI.

INS must be capable of sending an unprecedentedly large volume of information at a high speed, and one of the materials that meet such a new requirement is optical fiber.

The optical fiber is about the thickness of a hair at 0.125-mm, and light is transmitted through it, but for sending light without reducing its strength, its material must have a property of high purity to the greatest possible extent and a high transparency. In 1979, NTT led the Western advanced nations in succeeding in the development of an optical fiber whose capability of transmitting light is 1,000 times higher than the product of the U.S.'s Corning Co., thereby becoming the top such group in the world. Not only that, it developed technology called VAD by which the base material of optical fiber can be manufactured continuously and in a large size, thereby opening the way to the mass production of optical fiber.

Required for future optical fiber are to increase the capacity to lower circuit cost, to lower the loss for extending the repeating spacing and to lower the price to make it possible for the general subscribers system to use the optical fiber.

With regard to the increase of optical fiber capacity, a system capable of conducting transmission of 5,760 circuits in telephone equivalent per system, the same capacity as that of the existing coaxial cable system, has been realized; but NTT seems to have a plan to realize in 1987 a system of about 23,000 circuits in telephone equivalent per system, a four times larger capacity than that of the above-mentioned system.

As the INS age begins, requirements for computer also change. It becomes necessary to provide such functions of computer as high-speed computation, pattern, processing, and voice recognition with knowledge for inference.

It is reported that NTT succeeded in conducting inference processing by using eight arithmetic units at the "Fifth-Generation Computer International Conference 1984" held in Tokyo in 1984, but along with the realization of the fifth-generation computer, the development thereof yet remains to be done some time later.

The INS computer is a processor to conduct message exchange and information processing by realizing new type processings such as intelligent processing

in addition to the existing-type processings. Like this, the INS computer is what aims at the realization of an advanced intelligent communication system aimed at the improvement of network to intelligent type. NTT's research theme is to realize the number one machine in about 1990 and then to provide such machines with further advanced intelligent processing functions.

For realizing INS, there are such advanced research and development themes as those mentioned above, but as a matter of course, themes are not confined to these. Up to the time when the INS computer is developed, it probably will become all the more important to develop software. In preparation for the diversification of customer station equipment, it also will become important to improve the function of users sets and to develop telephone and non-telephone system equipment having new functions and high reliability. And, provided that "to be technically possible and to be usable by any person and serviceable to the world are different matters" (President Shinto), further efforts will be required for putting them to practical use.

A Technical Think Tank NTT Can Boast of to the World

There now has begun a telecommunications war wherein centering around NTT, such business groups as Daini Den-Den and U.S.'s IBM and ATT are engaging in a melee. Under such circumstances, NTT President Shinto says: "What counts is the capability of software development and the technical capability to master computer and communications equipment." NTT's technical research is now being promoted in four laboratories. They are telecommunications laboratories prefixed by Musashino, Yokosuka, Ibaraki and Atsugi, the place-names of their respective locations. The total number of employees of these laboratories is about 3,600, of which researchers number about 3,200. The characteristics of the four laboratories are outlined below.

The Musashino Telecommunications Laboratory works mainly on INS model system, communication network, exchange and communication processing system, electronic system, basic research, etc. Before spreading INS all over the country, the materialization of its model system got underway centering around the Mitaka-Musashino area, the location of the laboratory, from 28 September 1984.

The aim of this experiment lies roughly in the following three points. The first is to conduct comprehensive technical confirmation of whether the newly introduced technology displays the fixed function, with an eye also to the reliability, etc., of the system.

The second is to reexamine what service can be extended by using INS by getting users to directly come in touch with the constituent devices of the system, together with its usage and its necessity.

The third is that it is necessary to take steps for positively ascertaining, from a broad point of view of social science, cultural sciences, etc., what influence the introduction of INS will have on the individual life, the business activities, the regional administrative activities, etc., particularly the aspect of disadvantage that might possibly be produced depending on its usage.

In this model system research, this laboratory is conducting such works as composing technology of exchange, transmission system, customer station equipment, and communication processing system that constitute INS and technical confirmation test as a total system wherein these are combined.

In the communication network, research for seeking what the composition of communication network as infrastructure should be with an eye on the future of social activity and technology is very important.

Thus aiming at INS, research on the form of network and the controlling method of network consequent upon the digitization of network is being promoted. Further, in compliance with the diversification of service, this laboratory is conducting research on such matters as the method of arranging communication processing functions such as storage and conversion and the signal system and number system that are comprehensively applicable to telephone and non-telephone services.

In the research on the exchange and communication processing system, themes are research and application to practical use of such services as car telephone, fascimile communication, and data telephone through application of technology of electronic switching system of stored program control whose research and practical use have already been pushed.

With regard to the digital exchange system that forms the core of INS construction, the laboratory is endeavoring to attain cost reduction and miniaturization by positively utilizing the markedly advanced LSI technology. A trunk exchange (D 60) with a capacity of 20,000 erlang has already been put to practical use. Following this, the laboratory has also developed an exchange (D 70) of a 4,800-erlang capacity having subscriber's line, trunk line, or their combined functions. (Erlang is a unit indicating the "extent of use" of a certain thing, and the state of using a certain thing for an hour in full is referred to as "1 erlang." For instance, it is about 0.1-0.2 erlang in the telephone used usually for business.)

Research on the digital customer station equipment is also being pushed. When coming to use the digital fascimile communication, the quality is raised and the communication speed is greatly improved as compared with the present facsimile. The present communication speed is about 11 minutes for the A4 size, but this is shortened to about 10 seconds.

In the electronic switching equipment and the information processing system, the percentage the memory device accounts for in the coast, performance, floor space, of the system is large, and thus is economization and performance improvement are regarded as being important. However, there is yet no memory device that already meets the requirements of being capable of fetching and storing information contents at a high speed and yet small in size and low in cost. Thus research on the economization and capacity increase of magnetic disk memory, magnetic-tape type very large-capacity memory, semiconductor memory, is important, and the development of new technologies such as optical disk memory is also being waited.

As its main achievements of late from the standpoint of memory capacity, this laboratory has realized the practical use of a miniature high-density magnetic disk memory with a memory capacity of 3.2 G byte (equivalent to the information volume of about 8 years of morning newspapers) in a maximum that can work at high reliability and be maintenance free for a long time and a very large-capacity memory with a memory capacity of 472 G byte in maximum that automatically selects, records, and reproduces about 9,500 magnetic-tape cartridges in maximum.

In the basic research, research on new systems relating to communication network, exchange, transmission, and information processing, new man-machine interface for voice recognition and synthesis, and on new materials, new functional devices, which contribute to the realization of the above-mentioned matters is being conducted.

Besides, it also is the main work of this laboratory to make technical cooperation for solving various technical problems deriving from the business field, and thus this laboratory is contributing much to the smooth business operation. Further, the development of new parts and materials, including optical fiber and VLSI, becomes possible only after such common technologies as measurement, analysis, and processing have advanced. Thus the subjects of research of this laboratory are analysis technology of infinitesimal impurities, analysis technology of the state of configuration, defect of atoms at the atom level and high-accuracy polishing technology to make the surface of crystal and substrate far smoother than that of a mirror.

The principal role of the Yokosuka Telecommunications Laboratory is, to put the system to practical use. For instance, in putting the optical cable transmission system to practical use, its work is to attain the practical use of terminal equipment, repeater, maintenance and monitoring equipment, in cooperation with the Atsugi Laboratory in charge of light emitting and receiving elements and the Ibaraki Laboratory in charge of optical fiber cable and at the same time, to integrate them to be completed as a transmission system having necessary function and performance. In other words, this laboratory can be said to be a laboratory having a very close contact with NTT business and users.

Five items of transmission, compound communications, data communication, picture communication, and customer station equipment are the laboratory's main research fields.

For coping with the increase of demand for telephone service and further with the development and diversification of such new services as data communication, picture communication, and mobile communication in the future, it is essential to realize communications systems using new transmission media such as optical cable and communications satellite, centering on the digital multiplex transmission system, and to establish technology of network formation by them. Thus research on and realization of practical use of digital communication network, optical cable transmission system, radio transmission system,

satellite communications system, mobile communication system, etc., and research on transmission technologies such as digital signal processing and radio wave propagation are being conducted.

In the digital communication network, themes are research on and realization of practical use of digital network formation method as well as of toll system and local system synchronous terminal system that becomes the core of transmission network by connecting to the exchange, two-wire digital subscriber's line transmission system, digital coding technology of voice, etc.

Further, in the optical cable transmission system, research is being conducted on various systems such as very large-capacity, submarine relay, subscriber's line and in-plant following the short-distance medium and small capacity, long-distance large capacity and submarine non-relay systems that have already been put to practical use.

In the compound communications, what is aimed at is research on compound communications technology to handle various types of information such as voice, document, and pattern, distributed processing technology to conduct advanced processing at the terminals by distributing the functions of communications network, information processing center, etc. and further on technology to constitute INS for business offices that utilizes these technologies.

The data communication becomes the core of information revolution. The first full-scale data communication system in Japan is the (exchange barter) system of the local banks' association of Japan which began business in 1968. This system called "Local Banks' Association System" is what NTT began in 1966 and completed in three calendar years.

The completion of this system played an important role in promoting the informationization of Japan's society and gave impetus to the increase of information volume in Japan. Thereafter came the development of full-scale data communication in Japan as a result of the revision of the Public Telecommunications Law in 1971. The so-called "opening of communications circuit" resulting from the relaxation of restrictions on the circuit utilization until then contributed much to this situation.

With the digitization of communications network, various works become possible by data communication. This laboratory has developed data communication network architecture (DCNA) for rationally constituting the data communication network and making it possible for even different types of computers to mutually communicate. In DCNA, such measures as to divide the functions of data communication network roughly into information processing, communication processing and transfer and further to divide them into five levels are taken, thereby facilitating the expansion of functions.

Further, to economically meet a wide range of needs of data communication, an information processing system superior in price performance (?) is required. The DIPS-115 series adopts the 64-kilobit memory, and new technologies such as very high-speed logic LSI and high-density mounting system are employed in it.

Picture communication uses man's sense of vision. Thus it can realize a new form of communication that has not been attainable by the existing telephone and is an indispensable technology to INS. Concretely, research and practical application of facsimile communication system, facsimile equipment, video-conference system, and band-compression technology of picture communication, are being pushed. Besides, upon introducing various new types of services, to conduct research on function, performance, manipulability of customer station equipment as the interface between man and communications network is also this laboratory's work.

The Ibaraki Telecommunications Laboratory conducts research on optical fiber technology as its main work. This laboratory started research on low-loss fiber manufacturing technology in 1971, the year of its inauguration, in expectation of the arrival of the optical communications age in the future. Since then, it has strengthened its research setup on optical fiber and optical cable by stages. In 1982, it established a research setup for infinitesimal impurities analysis technology by application of radiation to push a further development of parts and materials research.

Thus far, this laboratory has been pushing development of optical fiber and optical cable, and research and practical application of various communications line technologies and parts and materials. Reviewing its principal achievements to date, the following can be cited.

1. Development of Very Low-Loss Optical Fiber

In the research on optical fiber manufacturing technology, this laboratory had since the start of that research in 1971 pushed research aimed at lowering transmission loss. As a result, in 1978 it established purity increasing technology of glass material and precision wire-diameter control technology of optical fiber, thereby succeeding in the development of a very low-loss optical fiber.

2. Development of VAD Method

In the research on optical fiber manufacturing technology, this laboratory had pushed accumulation of technologies aiming at the "development of self-reliant technologies," and in 1977, it succeeded in developing the VAD method (vapor-phase axial deposition method) as a continuous manufacturing method of base material for optical fiber. This method is said to have superior characteristics as optical fiber mass-production technology, such as not only being capable of axially continuously synthesizing optical fiber base material but also being fast in synthesizing speed of base material and further advantageous for the manufacture of large-size base material.

This laboratory had added many improvements to the VAD method thereafter, too, and in 1980, it succeeded in the development of a veryhigh-purity optical fiber by the VAD method and the realization of a VAD single-mode optical fiber with a unit length of 100 km. As a result of these achievements, VAD optical fiber was introduced in a large quantity into field tests and commercial

tests of various types of optical transmission systems, and its practical applicability was thus confirmed.

3. Development of Resist Material for FLSI

In the manufacture of VLSI, resist material on which very fine processing can be conducted plays an important role. This laboratory started research on resist material for electron-beam lithography in 1975 and succeeded in the development of various types of resist materials having a high sensitivity and a high resolution by 1979. These materials displayed a great power in the practical application of the 256 (K bit) VLSI developed at the Musashino Laboratory.

4. Practical Application of Various Types of Cables for Optical Transmission System

Together with the research on optical fiber manufacturing technology, research on various types of cables for optical transmission system was also promoted, and the medium and small capacity optical cable was used twice in the field test and put to practical use in 1981. For the large-capacity optical cable, confirmation of the practical applicability thereof is being pushed after its field test conducted between the Musashino Laboratory and the Atsugi Laboratory in 1982.

Optical fiber communication as the key network of INS plays an important role. Thus hereafter, too, research on optical fiber of a cheapter price and a further higher quality will probably be continued.

At the Atsugi Telecommunications Laboratory, the priority research items are VLSI optical communication system, digital communication, large-capacity satellite communications system and intelligent information processing for making up the INS.

Of these, the research on VLSI and semiconductor optical devices and new functional devices are to become the foundation for performance improvement and economization of various types of communications systems, and are thus expected to become all the more important hereafter.

Reviewing the details of research, in the research on IC, this laboratory is conducting research on design, test and high-reliability technology of VLSI. VLSI integrates a very large number of elements on a small piece of semiconductor. Such being the case, should there be even a single error in those many elements or in the wiring connecting between them, the whole body does not work. It is regarded as the key to the realization of VLSI to establish design and test method and high-reliability technology corresponding to the above-mentioned extreme complexity of VLSI.

Also, in VLSI, research on various technologies aimed at fine processing in particular, that is, new LSI process suitable for fining, fine pattern formation technology and fine processing equipment is being conducted. Further,

in order to improve the performance of device, it is necessary to take such measures as to adopt new materials and physical phenomena. For this, research on device and IC using compound semiconductor and superconductive material that have superior characteristics which are not in silicon LSI is also indispensable.

Reviewing its principal research achievements of late, since the importance of the role LSI plays in the communications systems has increased all the more, this laboratory started in fiscal 1975 comprehensive studies on basic technologies such as material, process, design technologies such as material, process, design technology and manufacturing equipment, and established 2-micron technology on the basis of various achievements of basic technologies such as growing technology of silicon large-caliber flawless crystal, photoresist material and electron-beam exposure method. By this, memories with a larger capacity became possible.

Recently, this laboratory has built up an automatic design system centering on the specification describing language HSL in the logic LSI field, thereby developing a 32-bit VLSI processor, etc.

On the other hand, in the functional device field, it has promoted research on GaAs IC, superconductive IC, semiconductor optical device, etc. With regard to GaAs single crystal to form the substrate of GaAs IC, this laboratory has realized a single crystal with a 3-inch diameter. Besides, it has conducted trial manufacture of 1-K bit memory and also a wide range of research on the whole field of Josephson technology, thereby producing many excellent results.

For pushing the digitization of communications network and at the same time promoting the performance improvement and economization of information control and processing system, optical communication system, satellite communications system and various types of customer station equipment toward the formation of INS, the role LSI and functional device should play is expected to grow greatly in the future, and thus it is considered that the place of activities for this laboratory will increase.

To Serve the World

In order that NTT is to be appraised as a full-fledged enterprise in the new stage of the liberalization of the telecommunications field and the appearance of rival companies, the wisdom and the power to foresee needs become the decisive factor.

NTT has newly spelled out reorganization in haste and revealed new services and new businesses in succession. There has come a move to switch the organization management and business planning which NTT, as a state organization, has long been pushing centering on the public corporation to those on a user-first basis.

It is a year since the INS model test at Mitaka, Tokyo, was started. It now is rumored that so far as it is observed in the test stage, INS has problems as to efficiency, etc. and still leaves many problems for its practical application. This means that there is still a gap between the dream and the reality of INS.

With regard to this point, however, NTT, too, has already finished research and investigation. In other words, there is already a general judgment that apart from the situation of INS fever, the final decisive factor for INS to be accepted by society is the attitude of end users in offices and homes.

It is not necessary to go to the length of seeing the example of technical competition between ATT (American Telephone & Telegraph Co) and IBM of the United States, technical research in the high technology field produces a better result when there is a competition in a good sense. However, technology must be useful for the world. The idea of NTT for the good of the world is what becomes the guideline for the management of President Shinto.

President Shinto has recently visited the United States, met ATT President Olson [as published] and concluded a comprehensive business tie-up with his company. NTT has already concluded a cross license (mutual exchange of patent) contract centering on the technical exchange with ATT, but the principal contents of the above-mentioned tie-up appear to be such matters as merchandise development and marketing, and operation control and management control of communications network in response to the liberalization of communications in Japan.

Like this, NTT, entering the new age, is extending positive activities all over the technology and management fields to become all the more useful existence for the world with President Shinto in the lead. With an engineering staff that NTT can boast of to the world, the development of further cheap and easy-to-use equipment would be possible, and systems further close to society and home would also come to be developed. The realization of more human communications society is indeed the aim of INS, and the technology backed by this philosophy is the characteristic of the NTT engineering staff. The noble duty of INS construction of President Shinto also will probably be supported and pushed by this technology. What is the useful technology for the world? The aim of giant NTT looms large.

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1 AUGUST 1986